Table D.11-2. A comparison of blue crab catches based on number, carapace width, weight and sex of crabs, and the number of pots fished at three stations near the Calvert Cliffs Nuclear Power Plant in Chesapeake Bay during 1979 (from Ref. 164).

	Kenwood Beach	Plant Site	Rocky Point	Total	Grand Mean
Total number of crabs	2,011	1,778	1,952	5,741	
Number of pots fished	291	295	293	879	
Crabs per pot	6.91	6.03	6.66		6.53
Percent at each station	35.3	30.8	34.0	100.1	
Total weight (kg)	305	258	301	864	
Weight per crab (g)	152	145	154		150
Legal-size crabs (≥127 mm)	1,516	1,296	1,538	4,450	
Non legal (<127 mm)	395	482	414	1,291	
Percent legal-size crabs	80.4	72.9	78.8		77.5
Legal-size crabs per pot	5.55	4.39	5.25		5.06
Mean width (mm)	144	139	143		142
Number of males	957	1,002	1,075	3,034	
Number of females	1,054	776	877	2,707	
Percent males	47.6	56.4	55.1		52.8

Table D.11-3. Summary of crab catch data collected near the Calvert Cliffs Nuclear Power Plant in Chesapeake Bay from 1968 through 1979 (from Ref. 164).

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Total number	239	2833	1557	4784	3046	3059	3970	4902	2845	2092	3476	5741
Total weight (kg)	48	367	240	711	449	480	632	778	392	378	552	864
Weight per crab (g)	200	132	154	150	145	159	159	159	138	181	159	150
Number ≥ 127 mm	206	2006	1191	3620	2202	2388	2942	4009	1922	1739	2601	4450
Number < 127 mm	33	827	366	1164	844	671	1028	893	923	353	875	1291
Percent ≥ 127 mm	86.2	70.8	76.5	75.7	72.3	78.1	74.1	81.8	67.6	83.1	74.8	77.5
Number males	158	1995	962	2660	1800	1753	2366	2381	1245	1082	1707	3034
Number females	81	838	595	2124	1246	1306	1604	2521	1600	1010	1769	2707
Percent males	66.1	70.4	61.8	55.6	59.1	57.3	59.6	48.6	43.8	51.7	49.1	52.8
Total pots fished	281	470	616	730	754	855	817	923	840	750	880	879
Number of crabs per pot	0.85	6.03	2.52	6.55	4.04	3.58	4.86	5.31	3.39	2.79	3.95	6.53
Market-size crabs per pot	0.73	4.27	1.93	4.96	2.92	2.79	3.60	4.34	2.29	2.32	2.96	5.06

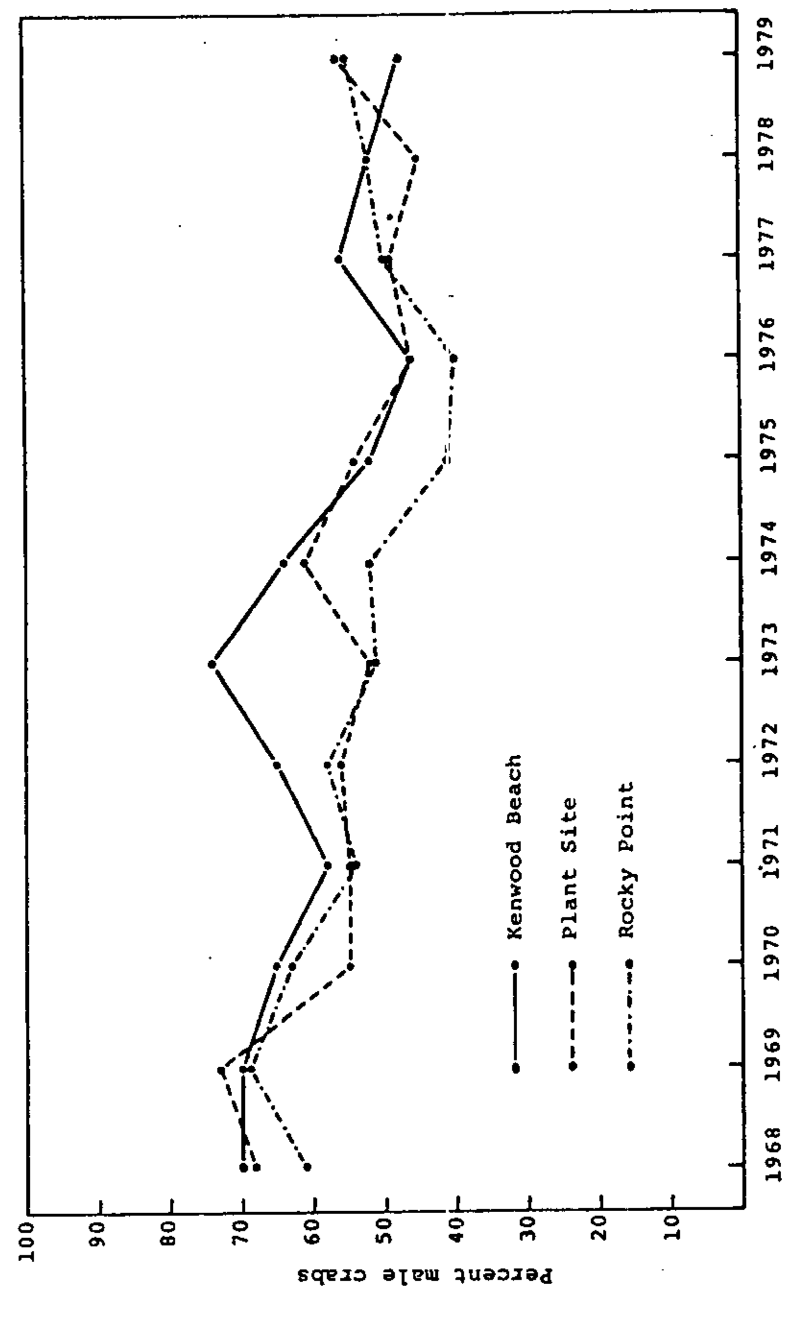

Figure D.11-1. Percent of annual catch made up of male crabs at three stations in Chesapeake Bay near the Calvert Cliffs Nuclear Power Plant from 1968 through 1979 (from Ref. 164).

APPENDIX D.12. - SUBMERGED SUBSTRATE STUDIES, CHESAPEAKE BAY-CALVERT CLIFFS, MARYLAND

(G.R. Abbe, ANSP)

D.12.1. Objective

To describe epibenthic and fouling communities in the vicinity of the plant site and to determine types and quantities of organisms found on artificial substrates at various depths.

D.12.2. Data Sources

Refs. 18-21.

D.12.3. Study History

Study done from 1968 to present, but data available for this report cover only 1968-1973.

D.12.4. Sampling Methods

- From 1970 through 1973, substrate panels were suspended at Kenwood Beach, the plant site, Rocky Point, and Cove Point (KB, PS, RP, and CP). (During 1968 and 1969, limited sampling was done from a single floating station at the plant site.)
- At each sampling depth (surface, 15 ft, and 30 ft), two wooden panels were attached to a Plexiglass strip.
- One panel was replaced monthly, and the other, quarterly. Each panel replaced was preserved in formalin and examined in the laboratory.

D.12.5. Analysis

- Species were counted and identified, and their dry weights and ash-free dry weights were recorded in the laboratory.
- Analysis-of-variance tests were done to test for differences among stations.

D.12.6. Results

- Analysis of variance showed no significant differences in biomass production from one station to another for a given depth or between depths at the same station (1972-1973).

- The number of species taken per station showed little variation in 1972-1973 but was lower than in previous years.
- The three major biomass producers collected throughout the study period were *Bimeria franciscana*, *Balanus improvisus*, and *Victorella pavida*.

D.12.7. Significance and Critique of Findings

Findings cannot be related to plant effects without operational data being available.

E APPENDICES

FINFISH STUDIES

APPENDIX E.1. - ICHTHYOPLANKTON ENTRAINMENT

(W.W. Wakefield, D. Cohen, and W. Yates, ANSP)

E.1.1 Objective

To estimate plant-induced mortality on entrained ichthyoplankton and macroplankton.

E.1.2. Data Source

Ref. 40.

E.1.3. Study History

One-year study.

E.1.4. Sampling Methods

Two 0.5-m, 202-μm-mesh nets with 5-gallon carboys as collecting cups were used in the intake embayment and in the discharge plume for 6-minute samples every 4-hours over a 24-hour period in June 1975. Larvae captured were placed in an observation table to determine mortality.

E.1.5. Analysis

Organisms were identified to the species level and counted, and the mortality level was determined.

E.1.6. Results

- The species collected, in order of decreasing abundance, were: *Gobiosoma bosci* (naked goby), *Gobiesox strumosus* (skilletfish), *Membras martinica* (rough silverside), *Anchoa mitchilli* (bay anchovy), *Syngnathus fuscus* (northern pipefish), and *Leiostomus xanthurus* (spot).

- Too few organisms were collected at the intake to allow estimation of latent mortality, but very high survival of organisms collected at the discharge was observed. At the beginning of the holding periods, for all species and samples combined, 82% were alive and properly oriented, 1% were disoriented (had trouble maintaining their equilibrium), and 17% were dead. At the end of the four hours, the corresponding figures were 79%, 2%, and 19%.

- Temperature data suggested that entrained water was diluted approximately 58% by the time it reached the discharge sampling station.

E.1.7. Significance and Critique of Findings

- The low numbers of organisms captured and the fact that discharge samples were diluted by ambient waters makes the reliability of results questionable.

- Because of difficulties with the sampling gear, this study was not repeated.

APPENDIX E.2. - ICHTHYOPLANKTON ENTRAINMENT STUDY

(EAI)

E.2.1. Objectives

To determine the species composition, abundance, and seasonal occurrence of ichthyoplankton and macroplankton exposed to entrainment and the magnitude of entrainment mortality.

E.2.2. Data Sources

Refs. 139, 166.

E.2.3. Study History

Work was conducted from April 1978 through July 1979.

E.2.4. Sampling Methods

- Six pumped samples (collected by a pump with a capacity of 1 m^3/min) were taken at the intake and discharge monthly in April 1978 and from October 1978 through March 1979; and were taken weekly from May through September 1978 and from April through July 1979.
- Three samples were taken during the day and three at night on each date.
- Individual intake samples were taken from three depths simultaneously.
- Pumped water was filtered on a larval table to minimize mechanical abrasion of sampled organisms; samples were preserved in 10% formalin.
- Organisms captured were identified to the species level, where possible, and counted.

E.2.5. Analysis

- A three-way ANOVA was run on data collected through March 1978 to test for intake-discharge, day-night, and seasonal (date) differences on log-transformed data.
- Analyses were run on the four major ichthyoplankton groups and five major macroplankton groups.

E.2.6. Results

- For ichthyoplankton through March 1979, four groups dominated the total catch: hogchoker eggs (71%), bay anchovy eggs (21%), naked goby larvae (3%), and bay anchovy larvae (2%) (Table E.2-1).

- For macroplankton, the mysid, Neomysis americana, and zoea of the mud crab, Rhithropanopeus harrisii, were the dominant forms through March 1979 (Table E.2-2).

- Ichthyoplankton were most abundant during the period when waters were warm (May-September); macroplankton were not as concentrated during summer and were abundant year-round.

- The only statistically significant intake-discharge (station) differences found were higher densities of bay anchovy larvae, naked goby larvae, and polychaetes at the discharge (Table E.2-3).

- Two peaks in bivalve spawning were observed in early September and the end of October. Late juveniles of Mya arenaria were not collected in large numbers.

- Abundances and patterns of seasonal occurrence of species found from April to July 1979 were similar to those observed in 1978 (Table E.2-4).

- Preliminary entrainment mortality data from 1979 are presented in Table E.2-5. Apparent survival rates tend to be high.

E.2.7. Significance and Critique of Findings

The higher abundances of ichthyoplankton in discharge samples suggest that sampling problems masked any entrainment effects, as was the case in zooplankton entrainment studies (see Appendix C.4). This sampling problem also raises questions about the validity of the mortality data. Thus, although this study provides a very detailed picture of seasonal patterns of ichthyoplankton and macroplankton abundance, it provides only preliminary data on the extent of entrainment losses. The data suggest that entrainment mortality is well under 100%.

Table E.2-1. Mean density (no./100 m^3), percent composition, and cumulative percent for ichthyoplankton collected in entrainment samples at CCNPP, April 1978-March 1979 (from Ref. 139).

SPP. NAME	NUMBER	%	CUMU. %
HOGCHOKER EGG	197.422	71.037	71.037
BAY ANCHOVY EGG	59.539	21.423	92.461
NAKED GOBY POST L	8.605	3.096	95.557
BAY ANCHOVY POST L	6.307	2.269	97.826
SPOT J	0.817	0.294	98.120
WINTER FLOUNDER EGG	0.677	0.244	98.364
UNIDENTIFIED BLENNY PRO	0.556	0.200	98.564
BAY ANCHOVY J	0.545	0.196	98.760
UNID FISH EGG	0.465	0.167	98.928
UNIDENTIFIED BLENNY POST	0.460	0.165	99.093
AMERICAN EEL J	0.386	0.139	99.232
ATLANTIC SILVERSIDE EGG	0.250	0.090	99.322
ATLANTIC SILVERSIDE POST	0.192	0.069	99.391
BAY ANCHOVY PRO L	0.170	0.061	99.452
ATLANTIC SILVERSIDE J	0.140	0.050	99.502
ROUGH SILVERSIDE EGG	0.129	0.046	99.548
NORTHERN PIPEFISH J	0.126	0.045	99.594
ATLANTIC SILVERSIDE PRO	0.121	0.043	99.637
ATLANTIC MENHADEN J	0.116	0.042	99.679
NAKED GOBY A	0.116	0.042	99.720
INSHORE LIZARDFISH J	0.111	0.040	99.760
SKILLETFISH POST L	0.067	0.024	99.785
BAY ANCHOVY A	0.063	0.023	99.807
WINTER FLOUNDER POST L	0.056	0.020	99.828
ATLANTIC CROAKER J	0.053	0.019	99.847
ATLANTIC CROAKER POST L	0.049	0.017	99.864
WINTER FLOUNDER J	0.043	0.016	99.880
NORTHERN PIPEFISH POST L	0.043	0.015	99.895
ATLANTIC MENHADEN POST L	0.034	0.012	99.907
HOGCHOKER PRO L	0.029	0.011	99.918
SKILLETFISH PRO L	0.028	0.010	99.929
FEATHER BLENNY J	0.024	0.009	99.937
STRIPED BENNY POST L	0.024	0.009	99.945
UNID FISH POST L	0.024	0.009	99.954
ATLANTIC SILVERSIDE J	0.024	0.009	99.962
NAKED GOBY J	0.023	0.008	99.971
STRIPED BLENNY J	0.018	0.006	99.977
WINDOWPANE POST L	0.010	0.004	99.981
HOGCHOKER POST L	0.010	0.004	99.984
NAKED GOBY PRO L	0.010	0.003	99.988
INSHORE LIZARDFISH POST	0.005	0.002	99.989
TIDEWATER SILVERSIDE POS	0.005	0.002	99.991
SPOT A	0.005	0.002	99.993
STRIPED BLENNY A	0.005	0.002	99.995
HOGCHOKER A	0.005	0.002	99.997
UNIDENTIFIED FISH J	0.005	0.002	99.998
OYSTER TOADFISH J	0.005	0.002	100.000

Table E.2-2. Mean density (no./100 m^3), percent composition, and cumulative percent for macrozooplankton collected in entrainment samples at CCNPP, April 1978-March 1979 (from Ref. 139).

SPP. NAME	NUMBER	%	CUMU. %
NEOMYSIS AMERICANA	658.149	29.359	29.359
R HARRISSII Z	257.831	11.501	40.860
POLYDORA IMM	219.191	9.778	50.638
XANTHIDAE Z	145.415	6.487	57.124
PELECYPODA	124.967	5.575	62.699
NEREIS SUCCINEA IMM	109.541	4.886	67.585
COROPHIUM	103.213	4.604	72.189
MONOCULODES EDWARDSI	96.868	4.321	76.510
SCOLECOLEPIDES VIRIDIS	92.739	4.137	80.647
PALAEMONETES Z	84.860	3.785	84.433
NEMATODA	76.322	3.405	87.837
SCOLECOLEPIDES IMM	50.148	2.237	90.074
NEREIS (NEANTHES) SUCCIN	47.431	2.116	92.190
NUDIBRANCHIA	20.684	0.923	93.113
CIRRIPEDIA CYPRIS	15.867	0.708	93.820
ACTINIARIA	15.587	0.695	94.516
MYSIDOPSIS BIGELOWI	15.385	0.686	95.202
GAMMARUS MUCRONATUS	11.433	0.510	95.712
MACOMA MITCHELLI	8.746	0.390	96.102
MELITA NITIDA	7.717	0.344	96.446
POLYDORA LIGNI	7.571	0.338	96.784
OSTRACODA	7.544	0.337	97.121
CIRRIPEDIA JUV	6.538	0.292	97.412
GAMMARUS	6.436	0.287	97.699
CNIDARIA (MEDUSAE)	5.291	0.236	97.935
LEPTOCHEIRUS PLUMULOSUS	4.384	0.196	98.131
TURBELLARIA	3.974	0.177	98.308
HIRUDINEA	3.702	0.165	98.473
ARGULUS	3.518	0.157	98.630
CIRRIPEDIA NAUPLII	3.350	0.149	98.780
CIRRIPEDIA A	2.943	0.131	98.911
MYSIDACEA JUV	2.133	0.095	99.006
CYMOTHOIDAE JUV	2.101	0.094	99.100
SAGITTA	2.099	0.094	99.193
EDOTEA TRILOBA	1.901	0.085	99.278
STYLOCHUS ELLIPTICUS	1.592	0.071	99.349
MACOMA BALTHICA	1.549	0.069	99.418
PARAPRIONOSPIO PINNATA I	1.517	0.068	99.486
ETEONE HETEROPODA	1.352	0.060	99.546
CRANGON SEPTEMSPINOSA Z	1.089	0.049	99.595
CALLINECTES SAPIDUS JUV	0.869	0.039	99.634
CRANGON SEPTEMSPINOSA	0.809	0.036	99.670
GAMMARIDEA	0.754	0.034	99.703
HYDROZOA (POLYP)	0.602	0.027	99.730
PALAEMONETES PUGIO	0.592	0.026	99.757
NEMERTEA	0.445	0.020	99.777
REPTANTIA M	0.420	0.019	99.795
DIPTERA L	0.381	0.017	99.812
PALAEMONETES	0.377	0.017	99.829
POLYDORA	0.271	0.012	99.841
HAUSTORIIDAE	0.269	0.012	99.853
POLYCHAETA IMM	0.255	0.011	99.865
STREBLOSPIO BENEDICTI	0.211	0.009	99.874
PALAEMONETES VULGARIS	0.206	0.009	99.883
E HETEROPODA IMM	0.198	0.009	99.892
CALLINECTES SAPIDUS MEG	0.197	0.009	99.901
HETEROMASTUS FILIFORMIS	0.192	0.009	99.909
CYCLASPIS VARIENS	0.177	0.008	99.917

Table E.2-2. Continued.

SPP. NAME	NUMBER	%	CUMU. %
OLIGOCHAETA	0.172	0.008	99.925
POLYCHAETA	0.168	0.008	99.932
PARASITIC COPEPODA	0.145	0.006	99.939
MYA ARENARIA	0.140	0.006	99.945
PARAPLEUSTES AESTUARIUS	0.132	0.006	99.951
LIMULUS POLYPHEMUS L	0.081	0.004	99.955
SPIONIDAE IMM	0.077	0.003	99.958
POLYPHEMIDAE	0.073	0.003	99.961
LEUCON AMERICANUS	0.072	0.003	99.965
SESARMA M	0.070	0.003	99.968
REPTANTIA Z	0.063	0.003	99.970
CHIRONOMIDAE L	0.058	0.003	99.973
AMPITHOE VALIDA	0.057	0.003	99.976
PARAHESIONE LUTEOLA	0.055	0.002	99.978
SCOLOPLOS	0.048	0.002	99.980
LEPTOCHELIA	0.042	0.002	99.982
GEUKENSIA DEMISSA	0.038	0.002	99.984
MOLGULA	0.038	0.002	99.985
STREBLOSPIO BENEDICTI IM	0.038	0.002	99.987
AMPELISCA ABDITA	0.029	0.001	99.988
AMYGDALUM PAPYRIUM	0.020	0.001	99.989
PARAPRIONOSPIO PINNATA	0.019	0.001	99.990
DIPTERA P	0.019	0.001	99.991
SCOLOPLOS IMM	0.019	0.001	99.992
CNIDARIA (POLYP)	0.015	0.001	99.993
ACANTHOCEPHALA	0.014	0.001	99.993
SPIONIDAE	0.014	0.001	99.994
PODON	0.014	0.001	99.994
LEPIDOPTERA L	0.014	0.001	99.995
BRYOZOA	0.013	0.001	99.996
ISCHADIUM RECURVUM	0.010	0.000	99.996
OLENCIRA PRAEGUSTATOR	0.010	0.000	99.997
EVADNE	0.010	0.000	99.997
NATANTIA Z	0.010	0.000	99.997
HYPANIOLA GRAYI IMM	0.005	0.000	99.998
GEMMA GEMMA	0.005	0.000	99.998
MULINEA LATERALIS	0.005	0.000	99.998
ARACHNIDA	0.005	0.000	99.998
STENOTHOIDAE	0.005	0.000	99.999
PARAMETOPELLA	0.005	0.000	99.999
PARACAPRELLA TENUIS	0.005	0.000	99.999
REPTANTIA JUV	0.005	0.000	99.999
PALAEMONETES INTERMEDIUS	0.005	0.000	99.999
PINNIXA CYLINDRICA Z	0.005	0.000	100.000
UCA Z	0.005	0.000	100.000
SABELLARIA VULGARIS	0.004	0.000	100.000

Table E.2-3. Results of analysis of variance: levels of statistical significance of date, time, and station, and their interactions on densities of selected taxa. Means and coefficients of variation of three replicate samples for selected ichthyoplankton and macrozooplankton collected by entrainment sampling at CCNPP, April 1978-March 1979 are also given (from Ref. 139).

	Effect								
Taxon	Date	Diel	Station	Date x Diel	Date x Station	Diel x Station	Arithmetic Mean	Geometric Mean	Coefficient of Variation[a] (%)
Hogchoker Eggs	0.001	0.001	NS	0.001	NS	NS	429.3	13.2	73
Bay Anchovy Eggs	0.001	0.01	NS	0.001	NS	NS	120.0	9.4	107
Bay Anchovy Postlarvae	0.001	0.001	0.001	0.01	NS	NS	12.6	3.2	46
Naked Goby Postlarvae	0.001	0.001	0.001	0.05	0.05	NS	17.4	5.4	53
Polychaetes	0.0001	0.0001	0.0001	0.0001	0.0001	NS	468.7	118.6	29
Amphipoda	0.0001	0.0001	NS	NS	NS	NS	356.9	41.7	110
Mysidacea	0.0001	0.0001	NS	NS	NS	0.001	879.0	99.7	64
Xanthidae	0.0001	0.0001	NS	0.0001	NS	NS	813.1	227.4	35
Pelecypoda	0.001	0.001	0.025	0.025	NS	0.05	245.9	18.5	83

(a) Snedecor and Cochran 1967, p. 330.

Table E.2-4. Species, life stages, numbers and months of availability of organisms collected by entrainment viability sampling at CCNPP, April - July 1979 (from Ref. 166).

	Life Stages					
	Egg	Prolarva	Postlarva	Juvenile	Adult	Availability
American eel				25		APR-MAY
Atlantic menhaden				26		APR-JUN
Bay anchovy	936		6	16	3	MAY-JUL
Oyster toadfish				1		JUL
Skilletfish			6			JUN-JUL
Rough silverside	3	3	4			JUN-JUL
Tidewater silverside		5	9			JUN-JUL
Atlantic silverside	1	65	1			MAY-JUL
Silverside spp.			17			JUN-JUL
Northern pipefish			1	2		JUN
Spot				78		MAY-JUN
Striped blenny			5			JUN-JUL
Blenny spp.		25	95			JUN-JUL
Naked goby	1	26	1,348	1		MAY-JUL
Winter flounder	2		2	23		APR-JUL
Hogchoker	1,157			2	3	JUN-JUL
Neomysis americana					6,666	APR-JUL
Mysidopsis bigelowi					3	MAY
Mysidacea					2	MAY-JUN
Palaemonetes spp.			1	2	110	APR-JUL
Crangon septemspinosa					1	MAY

Table E.2-5. Preliminary data on number examined, initial entrainment survival, and percent survival at scheduled intervals after collection for selected species/life stages collected at intake (INT) and discharge (DIS) stations at CCNPP, April-July 1979 (from Ref. 166).

		Number Examined	Mean Initial Entrainment Survival (S_e) (Percent)	Percent Live: Hours after Collection						
				0	4	8	16	40	64	88
American eel	INT	4	120.7*	100	100	100	100	100	66.7	66.7
Juveniles	DIS	21		100	94.7	94.7	94.7	94.7	94.7	94.7
Atlantic Menhaden	INT	1	24.0	100	100	100	100	100	100	100
Juveniles	DIS	25		100	100	100	100	33.3	33.3	33.3
Bay anchovy	INT	0	--	--	--	--	--	--	--	--
Juveniles	DIS	16		100	100	100	100	12.5	12.5	12.5
Bay anchovy	INT	2	--	100	100	100	100	0	0	0
Postlarvae	DIS	4		--	--	--	--	--	--	--
Spot	INT	37	82.0	100	95.4	95.4	95.4	86.4	77.3	72.7
Juveniles	DIS	41		100	100	100	100	100	100	100
Blenny spp.	INT	25	102.8*	100	100	88.9	66.7	44.4	33.3	11.1
Larvae	DIS	100		100	100	91.9	86.5	54.1	32.4	13.5
Naked goby	INT	896	56.1	100	98.6	95.7	90.4	81.9	55.7	29.8
Postlarvae	DIS	452		100	96.5	92.4	76.6	58.5	46.8	39.5
Naked goby	INT	10	10.5	100	50	50	50	50	50	0
Prolarvae	DIS	16		100	100	0	0	0	0	0
Winter flounder	INT	23	--	100	95.7	95.7	91.3	78.3	78.3	78.3
Juveniles	DIS	0		--	--	--	--	--	--	--

Table E.2-5. Continued.

		Number Examined	Mean Initial Entrainment Survival (S_e) (Percent)	Percent Live: Hours after Collection 0	4	8	16	40	64	88
Winter flounder Postlarvae	INT	2	--	100	100	100	100	100	100	100
	DIS	0		--	--	--	--	--	--	--
Silverside spp. Larvae	INT	10	106.5*	100	100	100	100	0	0	0
	DIS	94		100	95	85	60	50	25	10
Neomysis americana Adults	INT	5,619	81.7	100	97.6	95.2	92.8	85.3	78.5	72.1
	DIS	1,047		100	99.1	98.0	93.9	84.4	72.3	64.0
Palaemonetes Adults	INT	108	139.3*	100	100	98.7	96.1	93.5	92.2	92.2
	DIS	2		100	100	100	100	100	100	100
Bay anchovy Eggs	INT	627	190.3*	100	100	100	100	54.5	45.4	0
	DIS	309		100	100	100	100	100	0	0
Hogchoker Eggs	INT	835	132.5*	100	100	100	94.6	66.2	14.9	0
	DIS	322		100	100	100	94.8	86.2	10.3	0

* Entrainment survival exceeds 100 percent when percent survival at discharge is greater than at intake.

APPENDIX E.3. - ICHTHYOPLANKTON AND MACROPLANKTON

(ANSP)

E.3.1. Objective

To assess alterations in densities and distributions of nearfield ichthyoplankton and invertebrate macroplankton populations, which may have resulted from the operation of the plant.

E.3.2. Data Sources

Section 12.3 in Refs. 1, 2; Section 10.3 in Ref. 164; and Refs. 31, 39-42.

E.3.3. Study History

Two study periods, one in 1973 and another from 1975 through 1978.

E.3.4. Sampling Methods

- From April to November 1973, weekly tows collected surface and bottom samples from eight stations in the plant vicinity (Ref. 31).
- From 1975 through 1979, monthly macroplankton and weekly ichthyoplankton samples (in summer spawning period) were collected at various stations at or near the plant, as shown in Table E.3-1. These samples were collected simultaneously from surface, middle (5-m), and bottom (10-m) waters using 0.5-m, 202-μm-mesh nets. Three replicate tows were taken at each depth at each station.
- Samples were fixed and returned to the laboratory for identification and counting.

E.3.5. Analysis

- The 1973 data were used to estimate densities and species abundance.
- In 1975, nearfield and entrained samples were compared.
- The 1978 and 1979 data were analyzed for spatial patterns of each abundant taxon at the six sampling stations.
- Abundances of major taxa were compared for the 1976-1979 sampling years to determine whether local population densities had changed.

- Mann-Whitney U-tests were conducted on the near-plant and reference-station pairs to examine them for differences in distribution over 1978 and 1979.

- For the 1976-1979 period, monthly collections of a selected taxon at each station and time were graphed to illustrate trends in the data.

E.3.6. Results

- 1973 data

  -- Table E.3-2 lists the species collected in 1973.

  -- Bay anchovy eggs were by far the dominant component of the ichthyoplankton.

  -- No significant differences between stations were found.

- 1975 data

  -- Table E.3-3 presents monthly totals of eggs and larvae collected in 1975 at all stations and depths.

- 1976-1979 data

  -- Significant differences ($p < 0.05$) in catch size for the dominant species between near-plant and reference stations in 1978 are summarized in Table E.3-4.

  -- Near the plant, bay anchovy was the numerically dominant species of ichthyoplankton collected in 1976-1978, followed by hogchoker eggs (which were taken almost exclusively at the near-plant stations, Table E.3-5, Fig. E.3-1) and naked goby larvae (also significantly more taken at near-plant stations, Fig. E.3-2).

  -- The invertebrate component of the macroplankton catches was dominated by sea nettles, ctenophores, polychaetes, mysid shrimp, and amphipods.

  -- In 1977, many ichthyoplankton species had increased greatly in abundance over their 1976 levels.

  -- In 1978, despite the widespread occurrence of polychaetes in all areas, near-plant densities were significantly higher ($p < 0.05$) than reference-station densities (Fig. E.3-3).

  -- In 1978, mysid shrimp and amphipod densities were significantly higher ($p < 0.05$) at near-plant stations than at reference stations (Figs. E.3-4 and E.3-5).

-- In 1978, densities of bay anchovy eggs were lower at near-plant stations than at reference stations (Fig. E.3-6; Table E.3-6).

-- Distributions of most of the dominant organisms in 1979 were similar to those observed in 1978; higher densities of benthic oriented species (e.g., goby larvae) at the plant site are believed to result from those species choosing the rip-rap of the intake channel as their preferred habitat.

E.3.7. Significance and Critique of Findings

Localized concentrations of most of the dominant taxa of ichthyoplankton and invertebrate macroplankton were observed at the plant site during 1978 and 1979. This phenomenon may have resulted in higher entrainment than in other years; yet, since no depletion was observable in the plant vicinity, entrainment losses may not have seriously affected nearfield populations.

Table E.3-1. Summary of stations and depths sampled in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland, 1976-1978. All samples were collected at night except where noted (from Ref. 1).

Year	Monthly Stations	Weekly Stations	Depths	Number of Replicate Samples	Total Number of Samples Taken
1976	KB, PSC	PSC (daytime)	S-M-B	3	225
1977	KB, PSC, PS	PS	S-M-B at KB & PS B only at PSC	3	282
1978	KB, LB, D, PSC, PS, RP	D, PSC, PS	S-B at D S-M-B at all others	1	292

KB = Kenwood Beach
LB = Long Beach
D = Discharge plume
PSC = Plant Site Intake Canal
PS = Plant Site
RP = Rocky Point

S = Surface
M = Middle
B = Bottom

Table E.3-2. Species found in Chesapeake Bay ichthyoplankton sampling - 1973 (from Ref. 31).

Species	Number of samples with eggs	Number of samples with larvae
Anchoa mitchilli (bay anchovy)	120	4
Gobiesox strumosus (skilletfish)	0	2
Atherinidae (silversides)	2	21
Sygnathus fuscus (Northern pipefish)	0	1
Blenniidae (comb-toothed blennies)	0	1
Gobiosoma bosci (naked goby)	0	30
Trinectes maculatus (hogchoker)	34	0
Unidentified Osteichthyes	2	0

Table E.3-3. Monthly totals for eggs and larvae collected in 1975, combining all stations and depths (from Ref. 40).

Taxa and Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
						MONTH							
Eggs													
Bay anchovy					644	1,195	14	75					1,928
Hogchoker								2					2
Larvae													
Bay anchovy							31	7					38
Skilletfish						18	1						19
Silversides						1	1						2
Feather blenny							1						1
Naked goby						7	9	1					17
Total number of organisms					644	1,221	57	85					2,007

Table E.3-4. Summary of the significant differences between near-plant and reference stations for abundant taxa taken in monthly collections in 1978, as evaluated by the Mann-Whitney U-test (α=0.05) (from Ref. 1).

Taxa	Difference Among Stations
Ichthyoplankton	
Bay anchovy eggs	+
Bay anchovy larvae	-
Naked goby larvae	+
Hogchoker eggs	+
Macroplankton	
Chrysaora quinquecirrha	-
Mnemiopsis leidyi	-
Polychaeta	+
Neomysis americana	+
Amphipoda	+

(-) = no significant difference
(+) = significant difference

Table E.3-5. Mean density (in bottom samples) of hogchoker (*Trinectes maculatus*) eggs collected in 1978 in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (eggs/100 m^3). Eggs were taken from June 14 through September 26, 1978; monthly and weekly samples were taken in two different but concurrent studies (from Ref. 1). See Table A.3-1 for station identification key.

1978	KB	LB	D	PSC	PS	RP	near-plant combined	reference stations combined
Jun 14	0	3.5	0	0	2.3	0	2.3	3.5
22	NS	NS	6.8	0	0	NS	6.8	NS
28	NS	NS	71.8	8.0	22.0	NS	101.8	NS
Jul 5	NS	NS	0.7	1.2	174.3	NS	176.2	NS
10	0	0	69.3	8.8	445.9	0	524.0	0
21	NS	NS	443.0	840.6	1312.3	NS	2595.9	NS
29	NS	NS	161.4	1097.1	1380.5	NS	2639.0	NS
Aug 3	NS	NS	1145.8	1770.6	585.5	NS	3501.9	NS
8	0	0	288.0	365.0	92.7	53.5	745.7	53.5
15	NS	NS	19.6	28.0	297.8	NS	345.4	NS
24	NS	NS	62.2	1026.1	235.0	NS	1323.3	NS
Sep 1	NS	NS	5.4	3.7	0	NS	9.1	NS
26	0	0	0	0	0	4.2	0	4.2
Σ monthly	0	3.5	357.3	373.8	540.9	57.7	1272.0	61.2
Σ weekly	NS	NS	1916.7	4775.3	4007.4	NS	10699.4	NS
Total	0	3.5	2274.0	5149.1	4548.3	57.7	11971.4	61.2

NS = not sampled
near-plant stations = D, PSC, PS
reference stations = KB, LB, RP

Table E.3-6. Mean density (averaged over depth) of bay anchovy (*Anchoa mitchilli*) eggs collected in 1978 in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (eggs/100 m^3). Eggs were taken from May 23 through September 1, 1978; monthly and weekly samples were taken in two different but concurrent studies (from Ref. 1). See Table A.3-1 for station identification.

1978	KB	LB	D	PSC	PS	RP	near-plant combined	reference stations combined
May 23	327.1	243.6	4.1	0.9	2.3	209.3	7.3	780.0
31	NS	NS	70.0	30.6	0.7	NS	101.3	NS
Jun 8	NS	NS	2058.0	4733.6	1471.7	NS	8263.3	NS
14	697.7	384.9	13.6	5.6	136.8	713.4	156.0	1796.0
22	NS	NS	2.5	1.9	12.2	NS	16.6	NS
28	NS	NS	1.8	1.9	12.0	NS	15.7	NS
Jul 5	NS	NS	24.8	28.6	33.7	NS	87.1	NS
10	367.1	19.2	8.9	9.9	2.2	63.5	21.0	449.8
21	NS	NS	0	5.2	0	NS	5.2	NS
29	NS	NS	0.5	1.0	229.8	NS	231.3	NS
Aug 3	NS	NS	0.8	3.2	0	NS	4.0	NS
8	36.8	4.7	2.6	3.4	5.8	0.4	11.8	41.9
15	NS	NS	0	0	9.3	NS	9.3	NS
24	NS	NS	1.3	38.2	22.2	NS	61.7	NS
Sep 1	NS	NS	0.6	0	0	NS	0.6	NS
Σ monthly	1428.7	652.4	29.2	19.8	147.1	986.6	196.1	3067.7
Σ weekly	NS	NS	2160.3	4844.2	1791.6	NS	8796.1	NS
Total	1428.7	652.4	2189.5	4864.0	1938.7	986.6	8992.2	3067.7

NS = not sampled
near-plant stations = D, PSC, PS
reference stations = KB, LB, RP

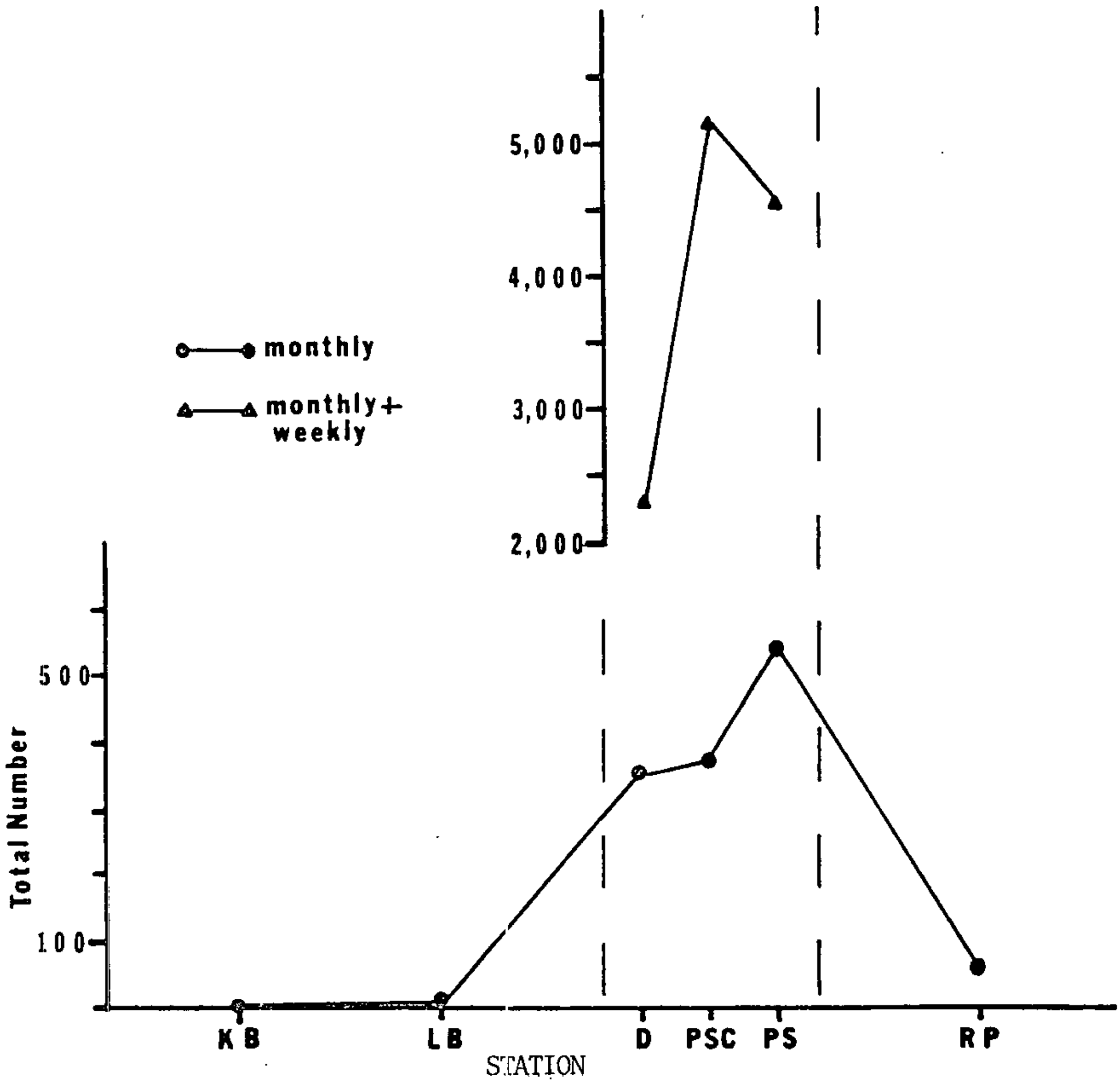

Figure E.3-1. Total number of hogchoker (*Trinectes maculatus*) eggs in bottom samples collected at each station in 1978 in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (from Ref. 1). See Table E.3-1 for station key.

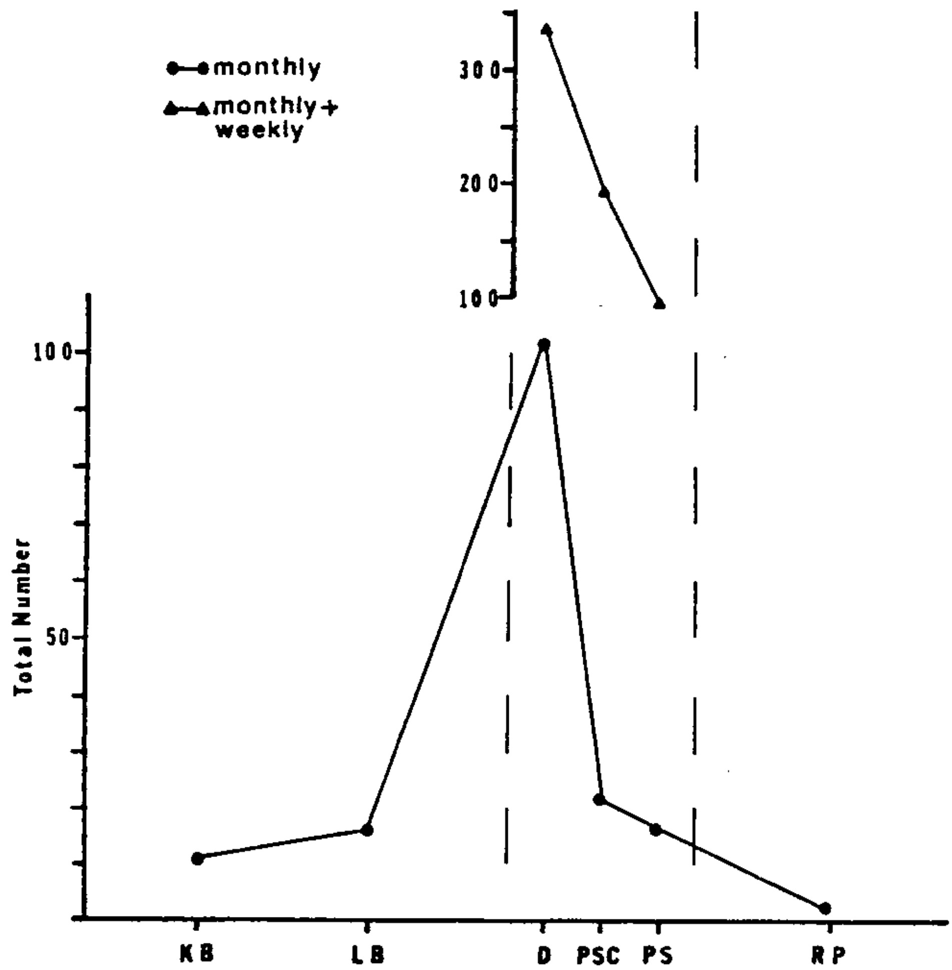

Figure E.3-2. Total number of naked goby (*Gobiosoma bosci*) larvae collected at each station in 1978 in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (from Ref. 1). See Table E.3-1 for station key.

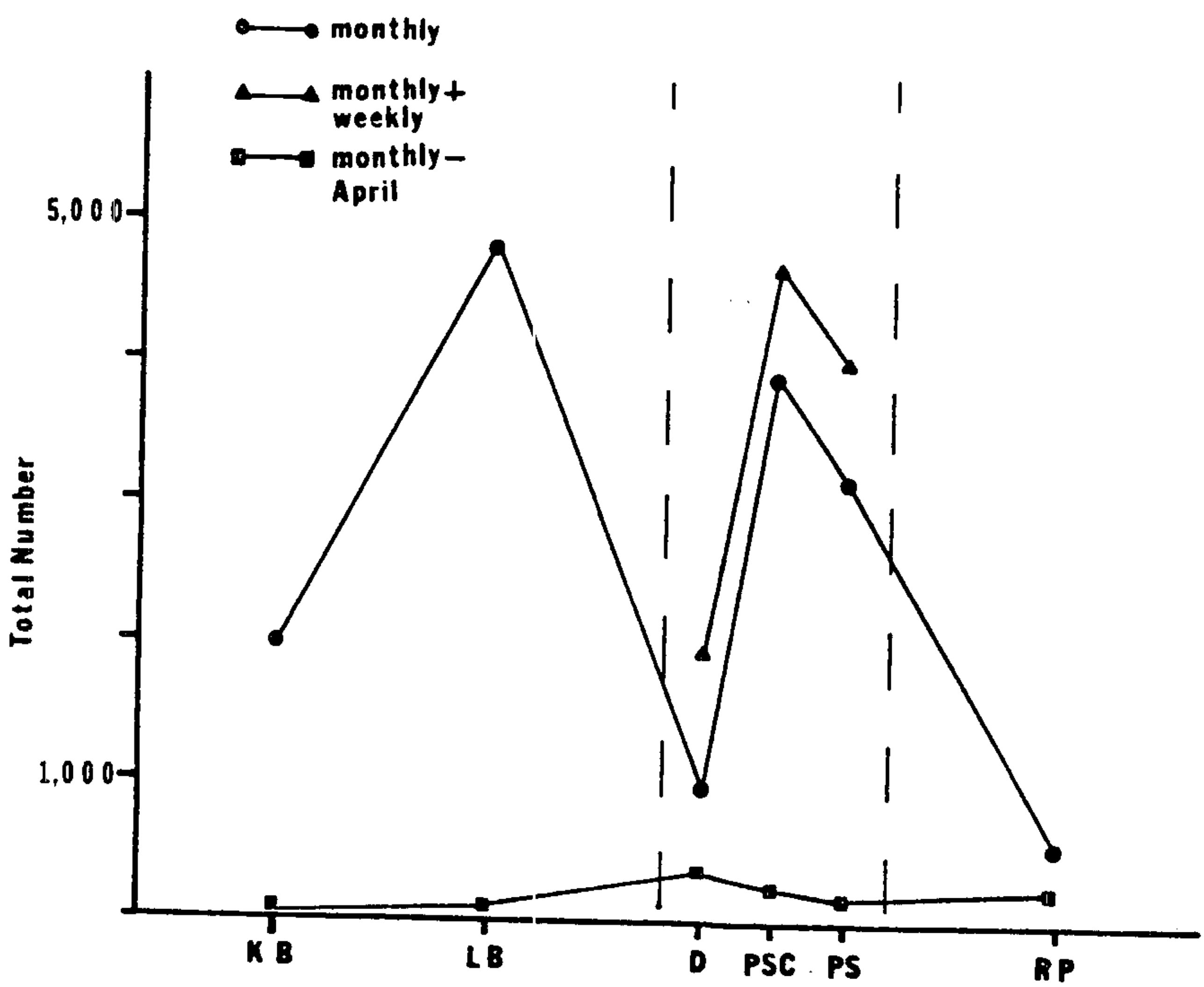

Figure E.3-3. Total number of polychaetes collected at each station in all of 1978, and the total excluding April values, in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (from Ref. 1). See Table E.3-1 for station key.

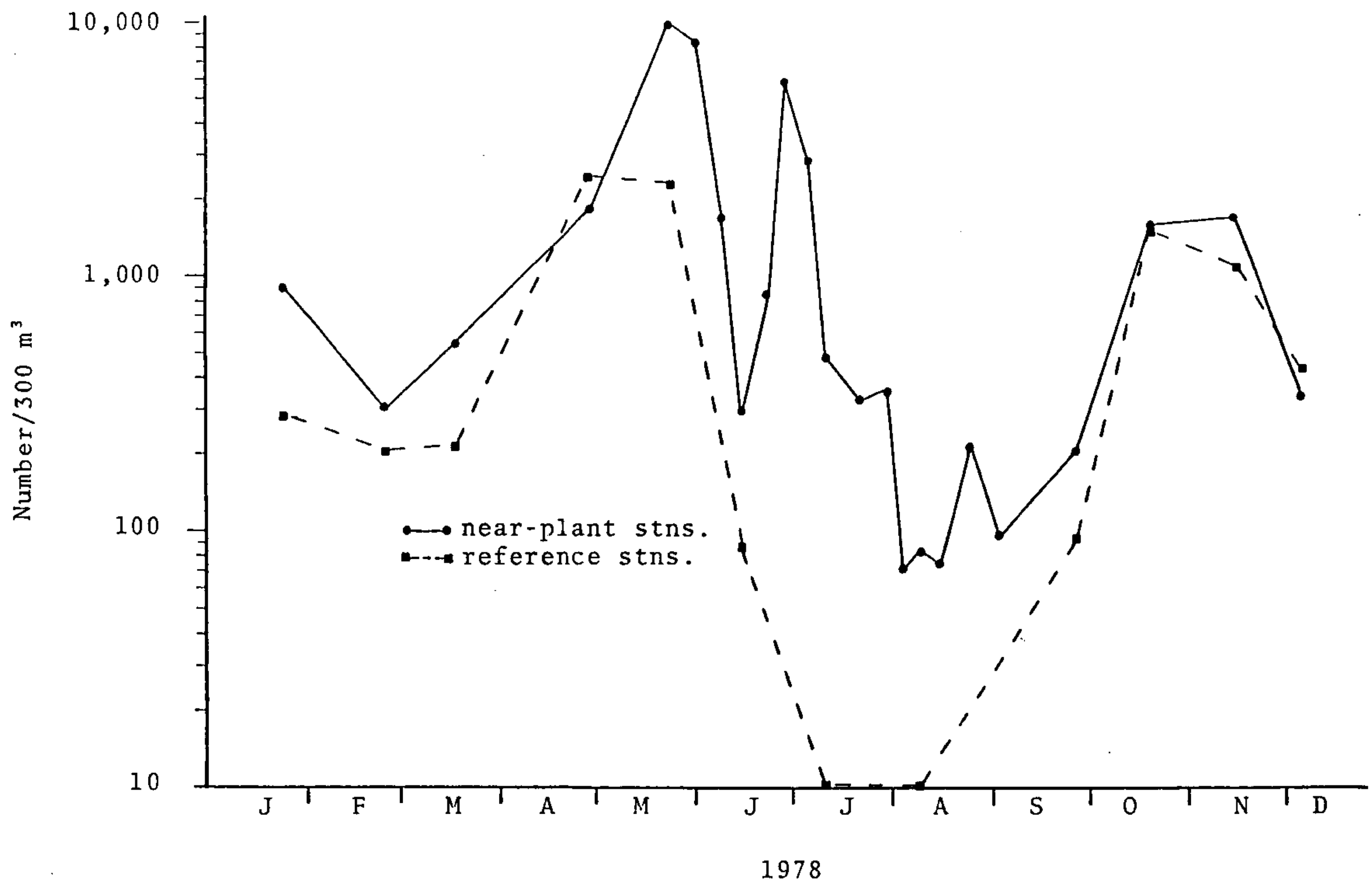

Figure E.3-4. Densities of mysid shrimp (*Neomysis americana*), averaged over depth, collected at near-plant and reference stations in 1978 in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (number of mysids/300 m^3) (from Ref. 1).

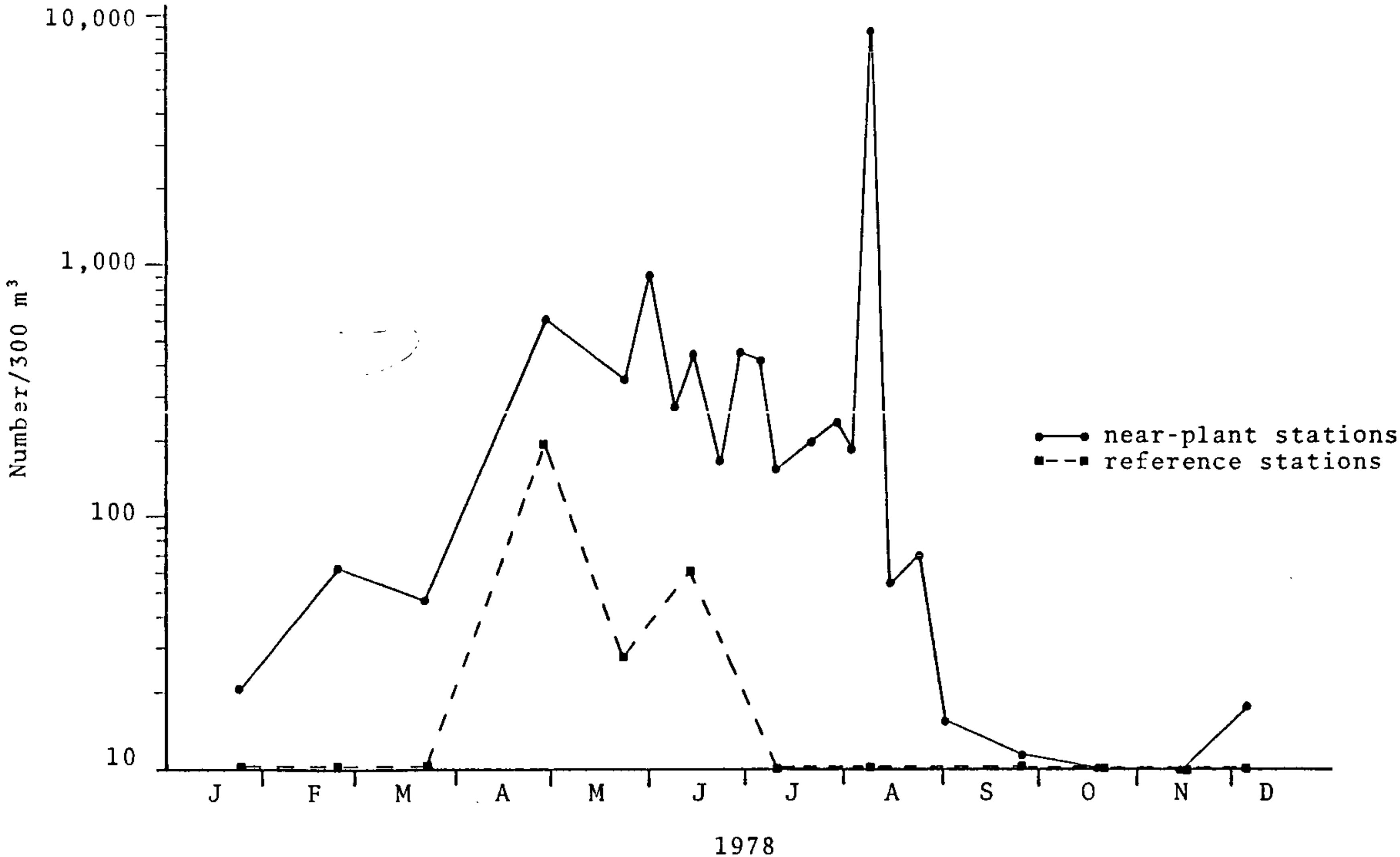

Figure E.3-5. Densities of amphipods, averaged over depth, collected at near-plant and reference stations in 1978 in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (number of amphipods/300 m^3)(from Ref. 1).

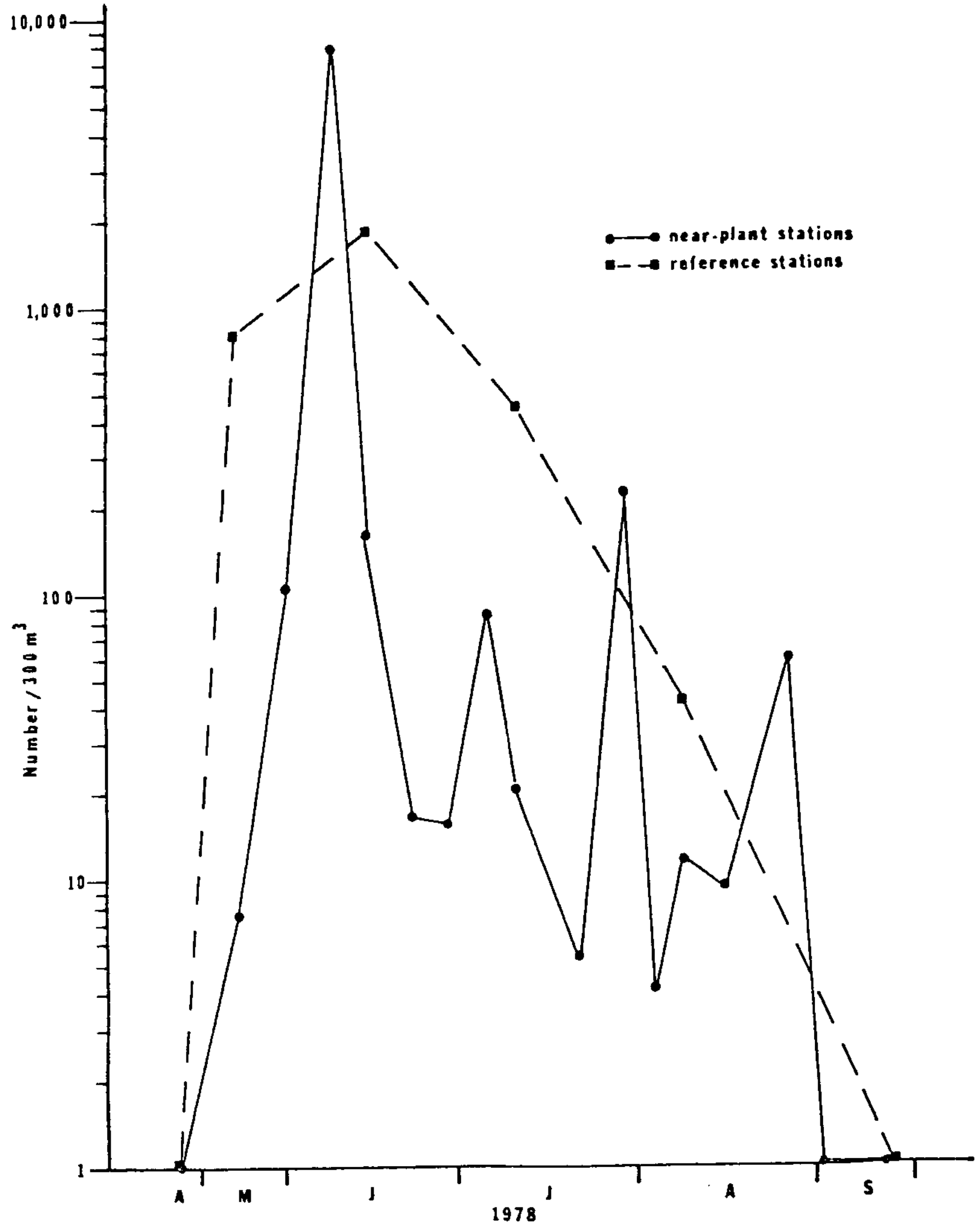

Figure E.3-6. Densities of bay anchovy (*Anchoa mitchilli*) eggs, averaged over depth, collected at near-plant and reference stations in 1978 in the vicinity of the Calvert Cliffs Nuclear Power Plant, Maryland (number of eggs/300 m^3) (from Ref. 1).

APPENDIX E.4. - MEROPLANKTON

(L. Lubbers and J. Mihursky, CBL)

E.4.1. Objective

To determine whether plant operations have affected ichthyoplankton and jellyfish densities and distributions.

E.4.2. Data Sources

Refs. 50, 59, 115-117.

E.4.3. Study History

Seven-year study (1971-78), but frequency of sampling varied among years.

E.4.4. Sampling Methods

- Sampling frequency was biweekly to bimonthly depending on season and year.
- One-meter plankton nets with 505-µm mesh and metered flow were used. Tows were 10 minutes, surface and bottom, at 7 stations, inshore and offshore, at Kenwood Beach (stations IA, IB), the plant site (stations IIA, IIB), Rocky Point (stations IIIA, IIIB), and a channel station off the plant site (station IIC). Salinity and temperature were measured at each station.
- The same gear was employed to sample along crossed transects oriented to a drifting buoy. Ten consecutive 5-min surface tows were made along each transect.

E.4.5. Analysis

- Annual means were calculated by station.
- Data were plotted.

E.4.6. Results

- Thirteen species of fish larvae and four species of fish eggs were taken (Table E.4-1).
- Blenny and goby eggs were taken only at station IIA, near the plant discharge, and only after plant operations began.

- A strong seasonal cycle in abundance was evident; most ichthyoplankton were taken in summer.
- Anchovy eggs (Table E.4-2) and larvae (Table E.4-3) were dominant in the catches.
- The channel station (IIC) tended to have the lowest ichthyoplankton densities, as did the inshore (A) stations (Fig. E.4-1).
- Vertical distributions of anchovies were homogeneous; silversides and blennies were concentrated near the surface; and gobies and croakers were concentrated near the bottom.
- At night, patches of anchovy and silverside larvae were on the order of 1.5 to 5 km in diameter.
- Based on average densities, no recirculation, and constant plant operations, egg entrainment would be 1.66×10^{10} eggs/yr and larval entrainment would be 3.13×10^{8} larvae/yr.

E.4.7. Significance and Critique of Findings

- The report reviewed here covered only a portion of the study period; as a result, the reported findings are incomplete.
- Ichthyoplankton populations at Calvert Cliffs are dominated by bay anchovy.
- No plant effects are evident in graphical presentations of these data. However, the gear study presented in Appendix E.9 suggests that the data on hogchoker and naked goby discussed here may not be representative of actual densities; thus, conclusions about plant effects on those species are suspect.
- Estimates of total entrainment do not take into account circulation patterns; as a result, they represent overestimates.

Table E.4-1. A list of ichthyoplankton species taken from 13 June 1974 through 28 June 1975 (from Ref. 50).

Larvae:	
Bay anchovy	Anchoa mitchilli
Goby	Gobiosoma spp. (probably bosci)
Silverside	Membras martinica
Silverside	Menidia menidia
Striped blenny	Chasmodes bosquinanus
Atlantic croaker	Micropogon undulatus
Skilletfish	Gobiesox strumosa
Northern pipefish	Syngnathus fuscus
Atlantic menhadden	Brevortia tyrannus
American eel	Anguilla rostrata
Winter Flounder	Pseudopleuronectes americanus
Spot	Leiostomus xanthurus
Hogchoker	Trinectes maculatus
Sciaenidae spp.	
Eggs:	
Bay anchovy	Anchoa mitchilli
Hogchoker	Trinectes maculatus
Goby	Gobiosoma bosci
Blenny	Chasmodes bosquinanus

Table E.4-2. Egg catch by month (number per 1000 m^3) (from Ref. 50).

SPECIES	1974 June	July	Aug	Sept	Oct	Nov	Dec	1975 Jan	Feb	Mar	Apr	May	June	Total	Percent of Total
Anchovy	123.1	91,272.2	249.6	0.7	4.1							58.1	1668.2	93,376.0	99.7
Hogchoker	99.7	139.0	10.8	0.2								1.6	3.4	254.7	0.27
Goby												1.8		1.8	<0.01
Blenny													0.3	0.3	<0.01
Unident. spp.	0.1													0.1	<0.01
Monthly Totals	222.9	91,411	260.4	0.9	4.1							61.5	1671.9	93,632.9	

Table E.4-3. Larval catch by month (number per 1000 m^3) (from Ref. 50).

Species	1974 June	July	Aug	Sept	Oct	Nov	Dec	1975 Jan	Feb	Mar	April		May		June		Total	Percent of Total
Anchovy		934.7	1.8	0.1				1.3		1.4	34.7	0.2	0.6	0.2	2.0	0.6	97[illegible]	81.3
Goby	0.3	17.4	2.3		0.2										1.0	6.3	23.9	2.0
Silversides	6.7	6.3	10.3	0.5									0.2		0.1	0.8	24.8	2.1
Blenny	1.1	15.6	2.1	0.3	7.6									0.5		3.3	30.5	2.5
Skilletfish	4.1	6.3	0.4	0.5	0.5										4.0	6.4	22 2	1.8
Croaker		0.8			0.8	8.4	2.2	84.5	1.9	2.1	3.8						104.5	8.7
Pipefish	0.7	0.2	0.2		0.3			0.1							1.6	2.9	6.0	0.5
Spot											0.8	0.1	0.5	0.1			1.5	0.1
Eel								0.3			0.5			0.1			0.9	0.07
Atl. Menhaden												1.7	0.2				1.9	0.2
Hogchoker		0.1															0.1	0.01
Sciaenidae spp.		0.1															0.1	0.01
Wntr. Flounder										0.2	8.0	0.1					8.3	0.7
Unident. spp.	0.2		0.3		0.2										0.3		1.0	0.08
MONTHLY TOTALS	13.1	981.4	17.3	1.4	9.6	8.4	2.2	86.2	1.9	3.7	47.3	2.1	1.5	0.9	9.0	20.3	1203.0	100%

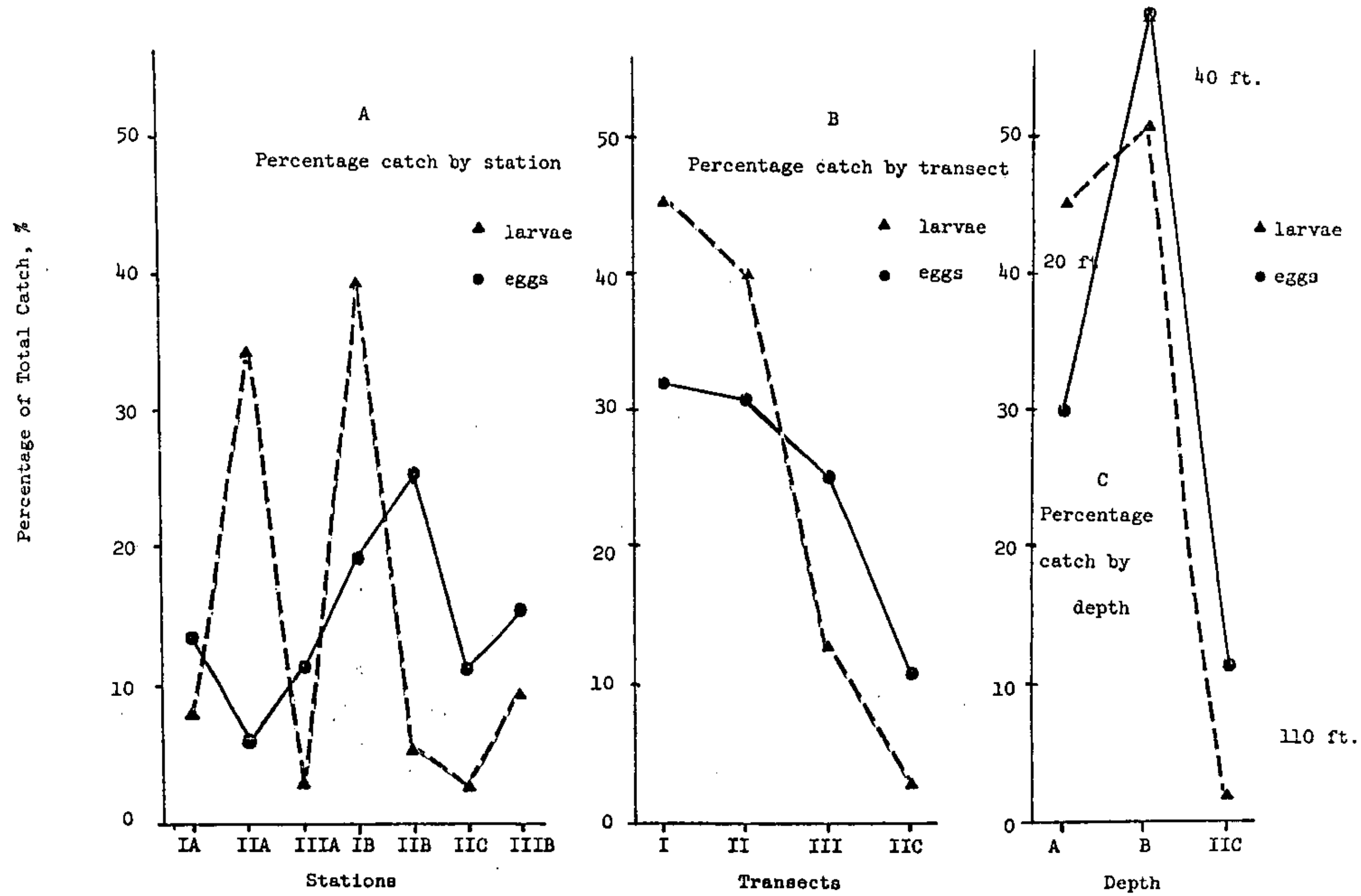

Figure E.4-1. Percentage catch of total eggs and larvae by station, transect, and depth--13 June 1974 to 28 June 1975 (from Ref. 50).

APPENDIX E.5. - ERDA ICHTHYOPLANKTON DATA ANALYSIS

(MMC)

E.5.1. Objective

To assess the effects of plant operations in ichthyoplankton densities.

E.5.2. Data Sources

Refs. 50, 59, 115-117.

E.5.3. Study History

Data were collected from 1971 to 1978, but frequency of sampling varied among years.

E.5.4. Sampling Methods

Sampling procedures are described in detail in Appendix E.4. Seven stations were sampled: inshore (A stations) and offshore (B stations) at Kenwood Beach (1A and 1B), the plant site (2A and 2B), and Rocky Point (3A and 3B), and one station in the main channel of the Bay (station 2C).

E.5.5. Analysis

- Only the four dominant ichthyoplankton groups were considered: bay anchovy eggs and larvae, hogchoker eggs, and naked goby larvae.

- Data were partitioned into preoperational (January 1971 through April 1975) and operational (May 1975 through April 1978) sets. Surface and bottom samples were treated separately.

- A nonparametric Friedman ANOVA was run on each data set, using only data from dates when the given ichthyoplankton group was taken from at least one of the seven stations. Highest density was given the lowest rank.

- In addition to the ANOVAs, frequency of occurrence of the given ichthyoplankton group at each station during preoperational and operational periods was determined. Differences in frequency of occurrence among stations were tested using a Chi-square test.

E.5.6. Results

- Results of Friedman ANOVAs run on bay anchovy egg and larval data are presented in Table E.5-1. No significant differences between stations were found during the preoperational period in densities of eggs and larvae, at surface or bottom. No significant differences in larval density occurred during the operational period, but significant differences did appear in egg density during that period at surface and bottom, and the channel station showed highest densities.
- Analyses of hogchoker egg data show significant differences between stations only in bottom samples taken during the preoperational period. Rocky Point and the channel station had highest densities (Table E.5-2).
- Analyses of naked goby larvae show a significant difference among operational-period, surface samples. The inshore plant-site station showed highest densities (Table E.5-3).
- Analyses of frequency of occurrence of all groups at all stations (Tables E.5-4 through E.5-7) showed a significant difference among stations only in the case of surface, operational-period data for naked goby larvae (Table E.5-7). In that case, frequency of occurrence at the inshore, plant-site station was high relative to occurrence at other stations.

E.5.7. Significance and Critique of Findings

- Changes in the distribution of naked goby larvae, which appeared during the period of plant operation, occurred only at the surface. This change could be related to the high velocity plant discharge, which would transport these normally demersal larvae to the surface. This distributional change does not appear to be detrimental since mortalities would not increase directly from the transport.
- The change in distribution of bay anchovy eggs could possibly be plant-related. The nonsignificant preoperational tendency for anchovy eggs to have highest densities at the channel station (2C) and Rocky Point (3B) is accentuated in the operational period, so that the differences among stations become significant. Since the rank of the inshore plant-site station (2A) relative to the other stations did not change between preoperational and operational periods, the change in egg distribution among stations would not appear to be a plant-related effect.
- Overall, no effects attributable to the power plant were detectable in distributions of the major ichthyoplankton groups (i.e., depletions at the plant site were not evident).

Table E.5-1. Mean ranks of stations, according to bay anchovy egg and larval density, during preoperational and operational periods; results of Friedman nonparametric analysis of variance are also presented (low rank indicates high values).

Time period	1A	2A	3A	1B	2B	3B	2C
				Eggs - Surface			
Preoperational	4.4	4.4	3.7	4.1	3.7	3.9	3.5
		$N = 16, \chi^2_{r_6} = 2.70, p > 0.05$					
Operational	5.1	4.8	4.4	4.0	4.1	3.3	2.2
		$N = 24, \chi^2_{r_6} = 30.5, p < 0.01$					
				Eggs - Bottom			
Preoperational	4.6	4.8	3.6	4.1	4.0	3.5	3.3
		$N = 23, \chi^2_{r_6} = 10.7, p > 0.05$					
Operational	5.2	5.3	4.2	4.0	3.9	3.0	2.5
		$N = 26, \chi^2_{r_6} = 36.02, p < 0.01$					
				Larvae - Surface			
Preoperational	3.6	3.4	4.5	4.1	4.3	3.9	4.2
		$N = 19, \chi^2_{r_6} = 3.5, p > 0.05$					
Operational	3.1	3.4	4.2	4.1	4.7	4.4	4.2
		$N = 18, \chi^2_{r_6} = 7.52, p > 0.05$					
				Larvae - Bottom			
Preoperational	4.2	4.2	3.5	4.4	4.1	4.0	3.5
		$N = 32, \chi^2_{r_6} = 4.98, p > 0.05$					
Operational	4.1	3.8	3.2	4.5	4.1	3.8	4.5
		$N = 27, \chi^2_{r_6} = 6.66, p > 0.05$					

Table E.5-2. Mean ranks of stations, according to hogchoker egg density, during preoperational and operational periods; results of Friedman nonparametric analysis of variance are also presented (low rank indicates high value).

	Stations						
Time period	1A	2A	3A	1B	2B	3B	2C
			Surface				
Preoperational	4.2	4.1	3.2	4.2	4.1	3.8	4.3
		$N = 9,\ \chi^2_{r_6} = 1.63,\ p > 0.05$					
Operational	4.1	2.9	3.2	4.7	4.2	4.4	4.4
		$N = 14,\ \chi^2_{r_6} = 8.01,\ p > 0.05$					
			Bottom				
Preoperational	4.8	4.7	3.2	4.6	4.3	3.7	3.0
		$N = 15,\ \chi^2_{r_6} = 15.93,\ p < 0.05$					
Operational	4.3	4.2	3.3	4.9	4.1	3.8	3.0
		$N = 22,\ \chi^2_{r_6} = 2.60,\ p > 0.05$					

Table E.5-3. Mean ranks of stations, according to naked goby larval density, during preoperational and operational periods; results of Friedman nonparametric analysis of variance are also presented (low rank indicates high value).

	Stations						
Time period	1A	2A	3A	1B	2B	3B	2C
			Surface				
Preoperational	4.4	3.0	4.2	3.8	4.5	3.7	4.4
		$N = 13, \chi^2_{r_6} = 4.53, p > 0.05$					
Operational	4.0	2.0	4.6	4.8	4.4	3.8	4.5
		$N = 14, \chi^2_{r_6} = 16.71, p < 0.05$					
			Bottom				
Preoperational	4.4	3.8	3.6	3.7	4.0	3.9	4.5
		$N = 24, \chi^2_{r_6} = 3.29, p > 0.05$					
Operational	4.2	3.6	2.9	4.5	4.3	4.0	4.5
		$N = 25, \chi^2_{r_6} = 10.17, p > 0.05$					

Table E.5-4. Frequency of occurrence of bay anchovy eggs at seven sampling stations over all survey years and result of Chi-square analysis of differences among stations.

Samples	Year	Number of Sampling Dates	Number Of Dates Eggs Taken	Number of Times Taken at Stations						
				1A	2A	3A	1B	2B	3B	2C
Surface	Preoperational									
	1971	7	1	0	0	0	0	0	0	1
	1972	19	6	3	4	3	3	3	3	4
	1973	16	8	5	5	7	6	7	6	7
	1974	12	2	0	1	1	2	2	2	2
	1975 (5 months)	6	1	0	0	0	0	0	1	0
	Proportion zeros (N=60)			.56	.44	.39	.39	.33	.33	.22
				$\chi^2_{(6)} = 1.91, p > 0.05$						
	Operational									
	1975 (7 months)	12	7	5	6	6	6	6	5	7
	1976	17	8	4	3	3	4	3	4	8
	1977	18	9	4	4	4	4	5	5	7
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=24)			.46	.46	.46	.42	.42	.42	.08
				$\chi^2_{(6)} = 4.31, p > 0.05$						
Bottom	Preoperational									
	1971	7	1	0	0	0	1	0	0	0
	1972	19	9	4	6	6	4	6	6	8
	1973	16	9	7	5	7	7	5	7	7
	1974	12	5	2	1	3	3	3	3	3
	1975 (5 months)	6	0	-	-	-	-	-	-	-
	Proportion zeros (N=60)			.46	.50	.33	.38	.42	.33	.25
				$\chi^2_{(6)} = 1.86, p > 0.05$						
	Operational									
	1975 (7 months)	12	8	8	5	6	7	7	8	8
	1976	17	8	4	6	5	6	7	7	6
	1977	18	10	5	6	7	5	6	6	8
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=26)			.35	.35	.31	.31	.23	.19	.15
				$\chi^2_{(6)} = 1.57, p > 0.05$						

Table E.5-5. Frequency of occurrence of bay anchovy larvae at seven stations over all survey years and result of Chi-square analysis of differences among stations.

Samples	Year	Number of Sampling Dates	Number Of Dates Eggs Taken	Number of Times Taken at Stations						
				1A	2A	3A	1B	2B	3B	2C
Surface	Preoperational									
	1971	1	2	1	0	0	0	0	0	1
	1972	19	6	3	2	3	3	2	4	3
	1973	16	5	4	4	2	3	1	3	1
	1974	12	5	1	3	0	1	2	1	3
	1975 (5 months)	6	2	0	1	1	0	0	1	0
	Proportion zeros (N=54)			.55	.50	.70	.65	.75	.55	.60
				$\chi^2_{(6)} = 2.52,\ p > 0.05$						
	Operational									
	1975 (7 months)	12	7	3	5	2	1	1	2	2
	1976	17	6	6	4	3	4	3	2	2
	1977	18	5	3	3	3	4	3	3	3
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=18)			.33	.33	.56	.50	.61	.61	.61
				$\chi^2_{(6)} = 3.48,\ p > 0.05$						
Bottom	Preoperational									
	1971	7	3	0	1	0	0	2	2	1
	1972	19	10	4	3	5	3	2	4	4
	1973	16	10	3	3	5	3	3	3	4
	1974	12	5	1	1	3	3	3	2	4
	1975 (5 months)	6	5	0	1	1	1	1	1	3
	Proportion zeros (N=54)			.76	.73	.58	.70	.67	.64	.52
				$\chi^2_{(6)} = 4.17,\ p > 0.05$						
	Operational									
	1975 (7 months)	12	11	5	5	6	4	2	6	4
	1976	17	9	5	5	6	4	8	4	5
	1977	18	7	4	5	6	4	5	5	3
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=27)			.48	.44	.33	.56	.44	.44	.56
				$\chi^2_{(6)} = 1.33,\ p > 0.05$						

Table E.5-6. Frequency of occurrence of hogchoker eggs at seven sampling stations over all survey years and result of Chi-square analysis of differences among stations.

Samples	Year	Number of Sampling Dates	Number Of Dates Eggs Taken	Number of Times Taken at Stations						
				1A	2A	3A	1B	2B	3B	2C
Surface	Preoperational									
	1971	7	0	0	0	0	0	0	0	0
	1972	19	3	2	2	2	1	1	1	0
	1973	16	3	0	1	2	0	0	1	0
	1974	12	3	1	1	1	1	2	1	2
	1975 (4 months)	5	0	0	0	0	0	0	0	0
	Proportion zeros (N=9)			.67	.56	.44	.78	.67	.67	.78
				$X^2_{(6)} = 0.31,\ p > 0.05$						
	Operational									
	1975 (8 months)	12	5	2	3	2	0	1	1	0
	1976	17	3	1	3	2	0	1	1	1
	1977	18	6	1	4	4	3	4	2	4
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=14)			.71	.29	.43	.79	.57	.71	.64
				$X^2_{(6)} = 1.10,\ p > 0.05$						
Bottom	Preoperational									
	1971	7	1	0	0	0	0	0	0	1
	1972	19	6	3	3	4	4	4	3	5
	1973	16	4	4	1	2	1	2	2	2
	1974	12	4	0	3	3	3	3	2	3
	1975 (4 months)	5	0	0	0	0	0	0	0	0
	Proportion zeros (N=15)			.53	.53	.40	.47	.40	.53	.27
				$X^2_{(6)} = 1.67,\ p > 0.05$						
	Operational									
	1975 (8 months)	12	8	3	3	2	1	2	3	4
	1976	17	7	2	4	4	2	2	3	6
	1977	18	7	4	4	6	4	5	5	4
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=22)			.59	.50	.45	.68	.59	.50	.36
				$X^2_{(6)} = 1.42,\ p > 0.05$						

Table E.5-7. Frequency of occurrence of naked goby larvae at seven sampling stations over all survey years and result of Chi-square analysis of differences among stations.

Samples	Year	Number of Sampling Dates	Number Of Dates Eggs Taken	Number of Times Taken at Stations 1A	2A	3A	1B	2B	3B	2C
Surface	Preoperational									
	1971	7	1	1	1	0	0	0	0	0
	1972	19	5	1	4	2	2	2	4	3
	1973	16	5	1	3	2	2	1	2	0
	1974	12	2	1	0	0	2	1	0	0
	1975 (4 months)	5	0	0	0	0	0	0	0	0
	Proportion zeros (N=13)			.69	.38	.69	.54	.69	.54	.77
				$X^2_{(6)} = 3.60, p > 0.05$						
	Operational									
	1975 (8 months)	12	6	1	5	0	0	0	0	1
	1976	17	5	1	3	1	0	0	4	0
	1977	18	3	1	3	0	0	1	0	0
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=14)			.79	.21	.93	1.00	.93	.71	.93
				$X^2_{(6)} = 28.67, p < 0.001$						
Bottom	Preoperational									
	1971	7	3	0	1	0	2	2	2	0
	1972	19	10	5	7	6	4	4	5	6
	1973	16	7	4	1	5	3	3	5	4
	1974	12	4	2	2	1	3	1	1	2
	1975 (4 months)	5	0	0	0	0	0	0	0	0
	Proportion zeros (N=24)			.54	.54	.50	.50	.58	.46	.50
				$X^2_{(6)} = 0.53, p > 0.05$						
	Operational									
	1975 (8 months)	12	7	4	1	5	5	3	3	4
	1976	17	9	3	5	5	3	6	4	3
	1977	18	9	2	4	6	2	3	3	1
	1978 (4 months)	4	0	0	0	0	0	0	0	0
	Proportion zeros (N=25)			.64	.60	.36	.60	.52	.60	.68
				$X^2_{(6)} = 3.87, p > 0.05$						

APPENDIX E.6. - 1976 TROIKA ICHTHYOPLANKTON STUDY

(K.V. Wood, et al., CBL)

E.6.1. Objective

To determine the effect of plant operations on ichthyoplankton densities.

E.6.2. Data Sources

Refs. 57, 58.

E.6.3. Study History

First year (1976) of a 2-year study. (See Appendix E.8 for follow-up study.)

E.6.4. Sampling Methods

- Sampling was done biweekly in July and August 1976, using two simultaneous troika tows, each consisting of three 1/2-m, 505-μm-mesh nets.
- Sampling was done every five hours over a 24-hour period.
- Oblique tows were made at Long Beach (LB, approximately 9-m depth), Rocky Point (RP, approximately 12-m depth), and in the intake channel (IC); a tow at 12-m depth was made at the curtain wall (CW).
- All organisms captured were identified to the species level and enumerated. Densities were calculated based on volume filtered.

E.6.5. Analysis

ANOVAs and Student-Newman-Keuls tests were run on untransformed data.

E.6.6. Results

- Mean densities of bay anchovy eggs, bay anchovy larvae, hogchoker eggs, and naked goby larvae, by station, date, and time, are presented in Figs. E.6-1 through E.6-4.
- Maximum egg and larval densities for dominant species (bay anchovy and hogchoker eggs; bay anchovy and naked goby larvae) all occurred in late July.

- Mean densities of anchovy eggs were from 6 to 27 times higher at the reference stations than at the intake channel station. These differences were most pronounced during hours of darkness (2100 to 0500 hours). The highest observed density was 25,000/1,000 m^3 at reference station LB. Mean densities of hogchoker eggs were from 3 to 17 times higher at the plant-site stations (CW and IC) than at the reference stations (RP and LB). The highest observed density was 6,400/1,000 m^3 at station IC. In general, egg densities were higher at night at both reference and plant-site stations.

- Mean densities of anchovy larvae were higher at night at all stations throughout the study period. Diel density variations were not pronounced for naked goby larvae.

- Statistical analyses indicated that bay anchovy eggs occurred in significantly lower densities at the plant-site stations in 40% of the July samples that had significant station-to-station differences. However, for bay anchovy larvae, there were no significant differences between catches at the plant-site stations and catches at the reference stations. Statistical analyses indicated that hogchoker egg densities were significantly higher at the plant-site stations for 44% of the July and August samples. Statistical analyses of naked goby larval catches indicated that significantly higher densities occurred at the power plant station IC for 45% of the July samples, but were higher at station CW for only 18% of these samples.

- A special study of the effect of tow length on density estimates indicated that short-distance tows provide a good index of maximum and minimum egg densities of dominant species in a sampling area. Longer tows provide a good index of mean densities in a region due to integration of ichthyoplankton patches over the sampling area. In general, larval density estimates were less sensitive to tow length than egg density estimates.

E.6.7. Significance and Critique of Findings

- The low density of bay anchovy eggs at the plant site suggested that depletion might be related to plant operations; however, the following year's study (see Appendix E.8) suggested that anchovies spawned in deeper waters (such as those at the reference stations) rather than in the shallower waters present at inshore plant-site stations. The limited number of sampling stations employed in most of the ichthyoplankton studies complicates interpretation of the findings.

- Higher abundances of naked goby larvae and hogchoker eggs at station IC suggest that the intake channel is a preferred spawning habitat for these species.

- The failure to transform data prior to analysis makes statistical results questionable.

- Oblique sampling may underestimate hogchoker eggs and naked goby larvae (see Appendix E.9).

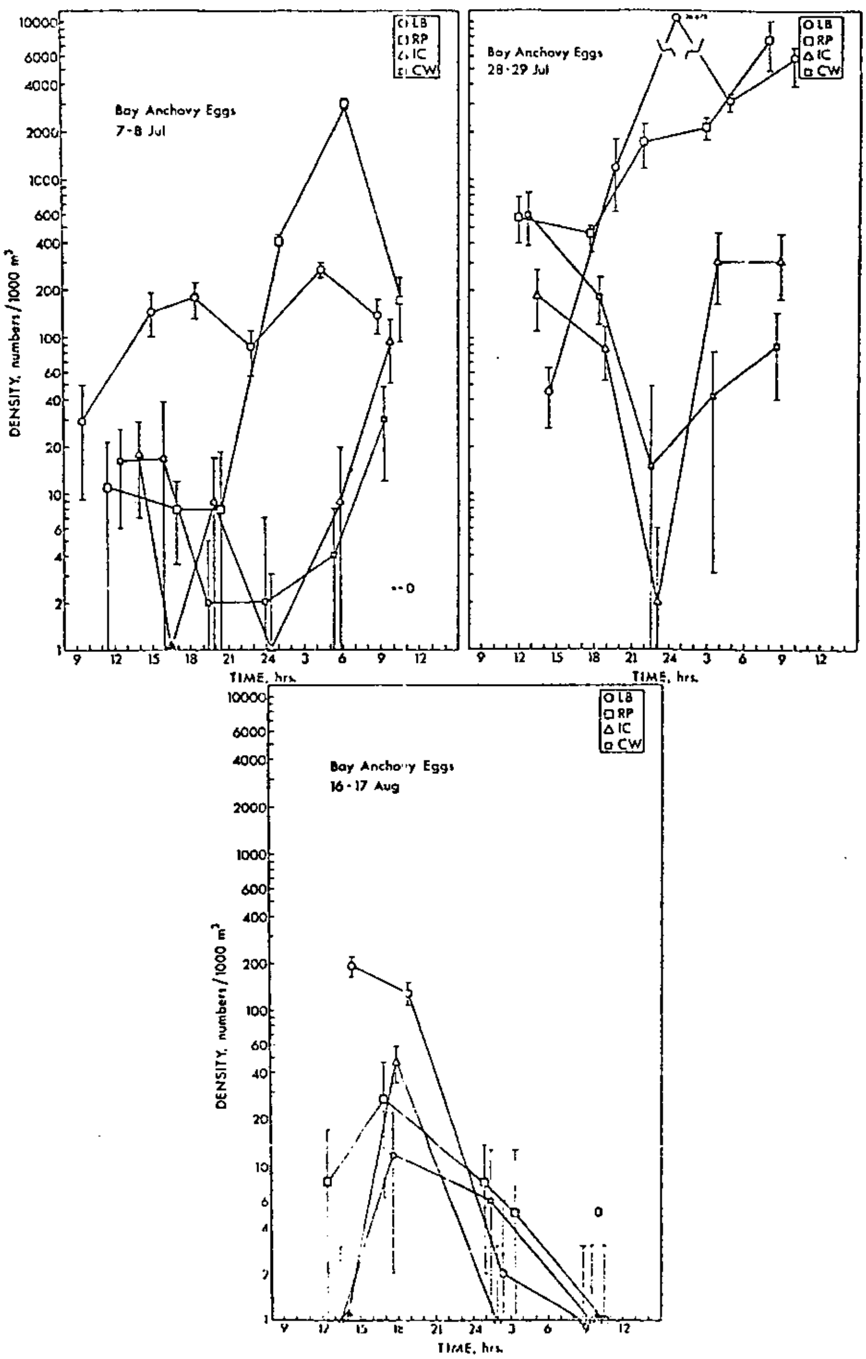

Figure E.6-1. Mean densities of bay anchovy eggs collected in July and August 1976. Vertical bars represent one standard deviation of the mean. Stations are indicated in the key. Densities are the mean of each troika tow (six samples) (from Ref. 58).

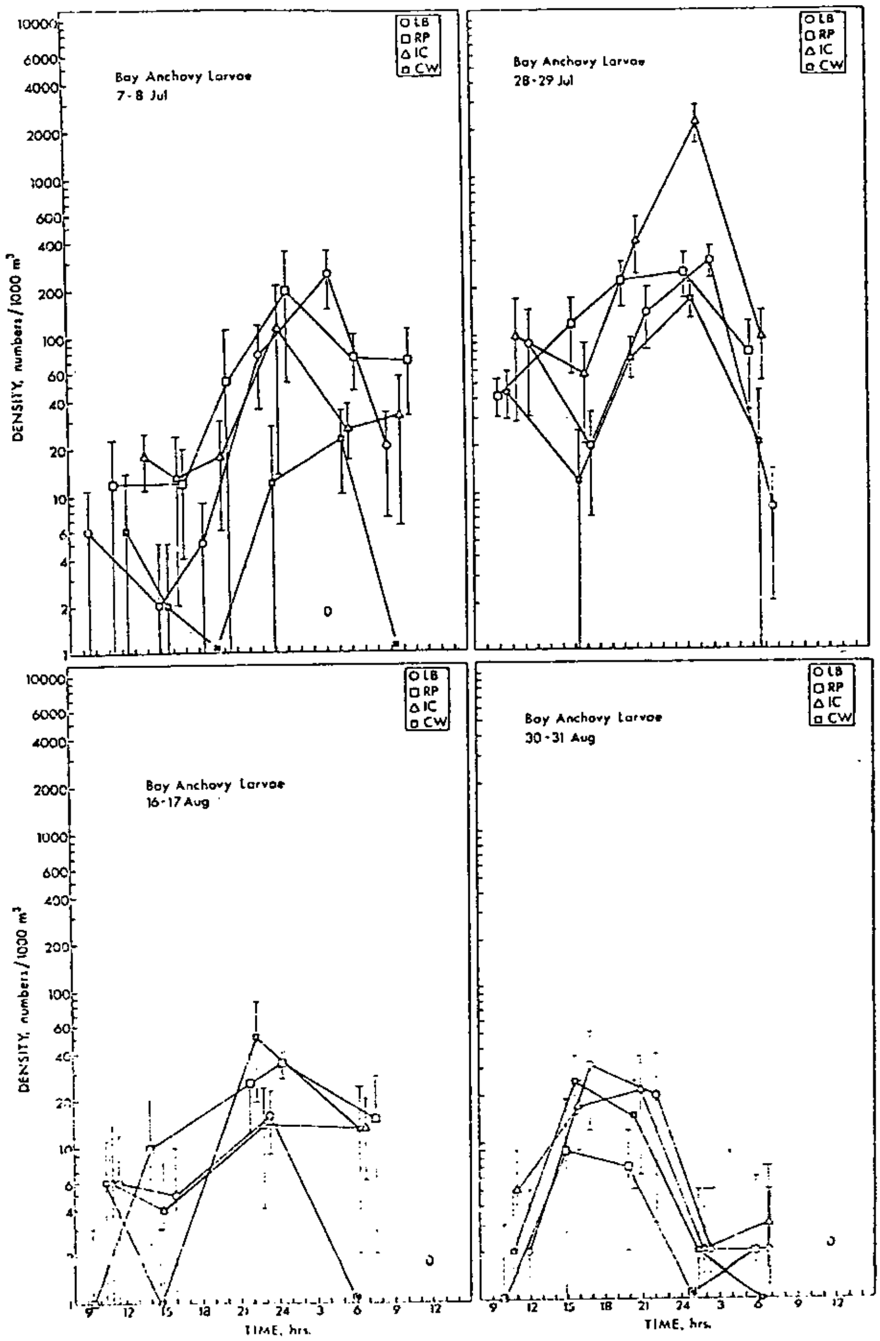

Figure E.6-2. Mean densities of bay anchovy larvae collected in July and August 1976. Vertical bars represent one standard deviation of the mean. Stations are indicated in the key. Densities are the mean of each troika tow (six samples) (from Ref. 58).

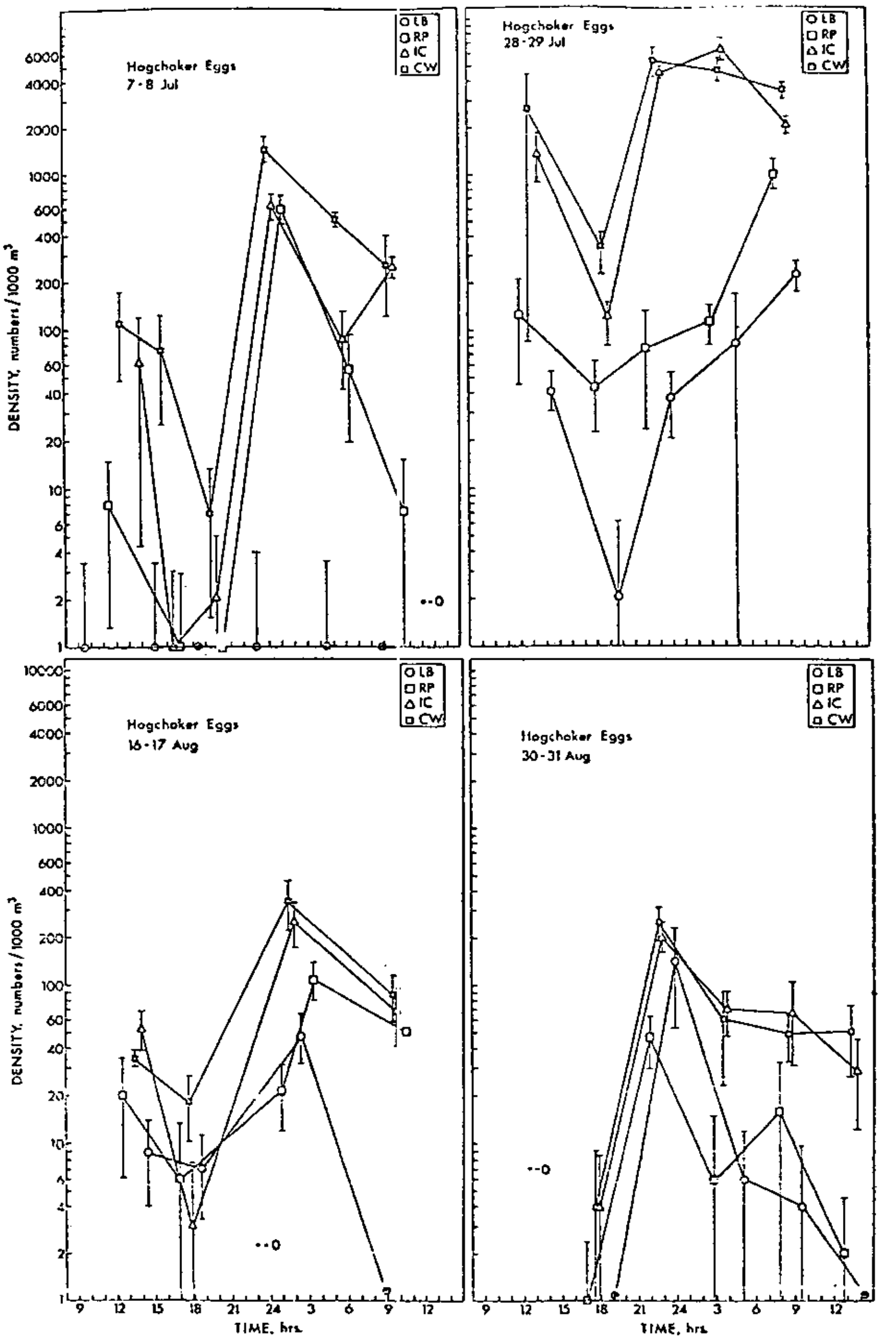

Figure E.6-3. Mean densities of hogchoker eggs collected in July and August 1976. Vertical bars represent one standard deviation of the mean. Stations are indicated in the key. Densities are the mean of each troika tow (six samples)(from Ref. 58).

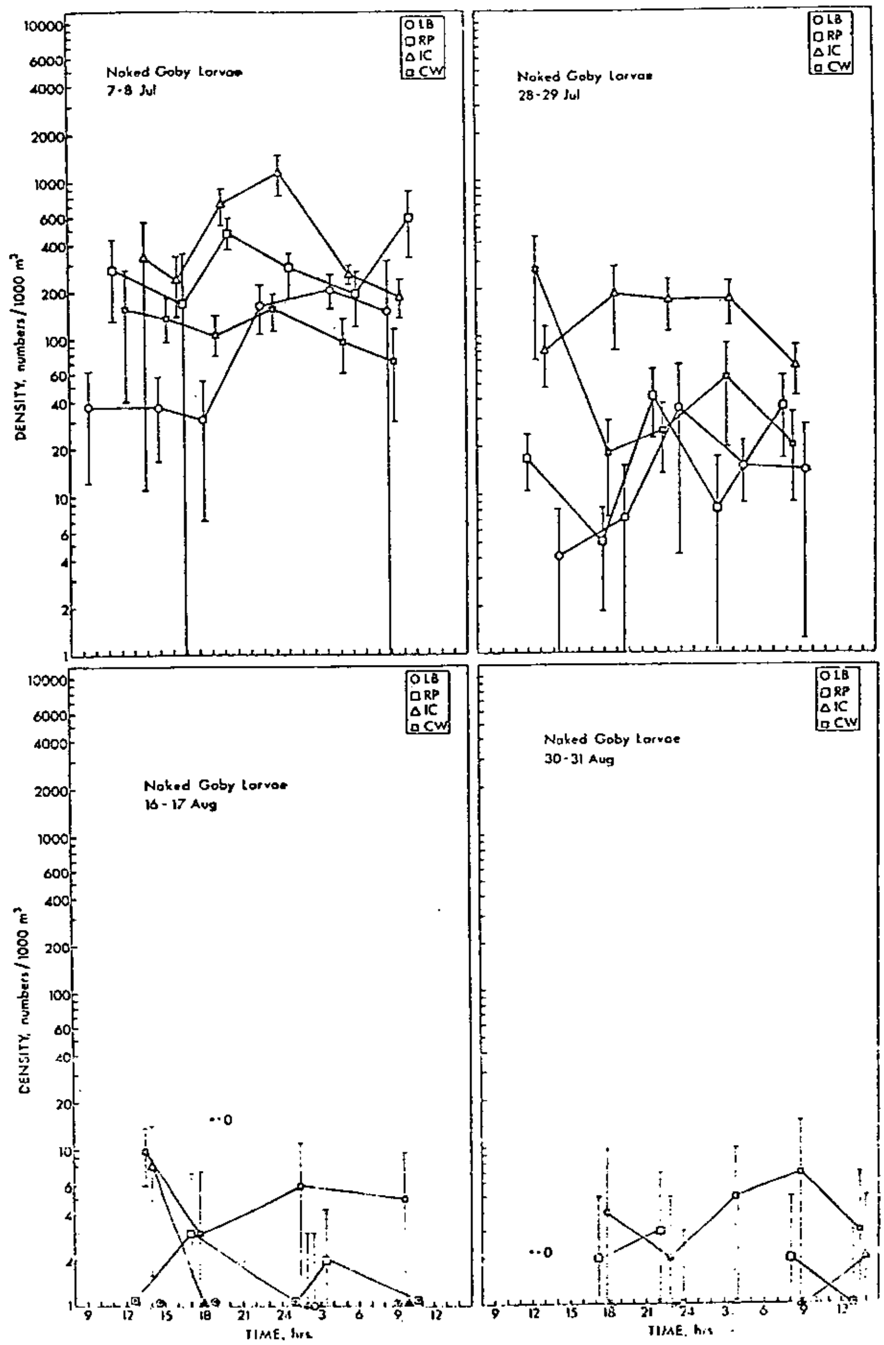

Figure E.6-4. Mean densities of naked goby larvae collected in July and August 1976. Vertical bars represent one standard deviation of the mean. Stations are indicated in the key. Densities are the mean of each troika tow (six samples)(from Ref. 58).

APPENDIX E.7. - 1976 TROIKA ICHTHYOPLANKTON DATA ANALYSIS (MMC)

E.7.1. Objective

To determine whether plant operations affect densities of fish eggs and larvae.

E.7.2. Data Sources

Refs. 57, 58.

E.7.3. Study History

First year (1976) of a two-year study.

E.7.4. Sampling Methods

- Six simultaneous tows were made with 0.5-m nets (505-μm mesh) at 4 locations--oblique tows at Long Beach, Rocky Point, and the plant's intake channel; discrete tows at the 10-m depth in the intake channel (curtain wall).
- Sets of samples were taken at least 5 times during each of four 24-hour periods during July and August 1976 (see Ref. 58 for additional details).

E.7.5. Analysis

- Null hypothesis - ichthyoplankton densities were similar at all locations.
- Densities expressed as number per 1,000 m^3 of water were log transformed to normalize the distributions and stabilize the within-station time variances.
- A hierarchical ANOVA, testing for differences among stations within time periods, was applied to the transformed data set.
- When ANOVAs revealed significant differences, location means were contrasted using Scheffe's method (Ref. 124).
- Minimum detectable differences between location means were calculated using a power-of-the-test procedure (Ref. 124).

E.7.6. Results

- The ichthyoplankton community was dominated by four groups: bay anchovy eggs and larvae, hogchoker eggs, and naked goby larvae.

- For bay anchovy egg data, significant differences between stations were found on two of three dates when sufficient egg data were available for analysis (Table E.7-1). For July 7-8, plant-site values are significantly lower than reference-station values (Table E.7-2). For the other dates, the Scheffe method does not show where the difference occurs, but plant-site densities are much lower than reference values.

- For hogchoker egg data, a significant location effect occurred on the first 2 sampling dates (Table E.7-3). Plant-site densities were higher than reference values, and discrete-depth, intake-channel values were higher than oblique intake-channel values (Table E.7-4). However, contrasts between location means show that these differences were only significant on July 7-8; large error variances probably account for the absence of other significant contrasts.

- For bay anchovy larval data, no significant station effects were observed (Table E.7-5).

- For naked goby larval data, a significant station effect was found on 3 of 4 sampling dates (Table E.7-6). The only consistent pattern in densities is that Long Beach values are lowest; however, contrasts of location means show no consistency in significant location differences (Table E.7-7).

- A tabular summary of results of analyses (Table E.7-8) shows that conflicting patterns of high and low abundance occur for the different ichthyoplankton groups.

- Minimum detectable differences between location means were calculated for each data set (Table E.7-9). The most notable result is that for bay anchovy larvae the minimum detectable differences on 2 of 4 dates are more than twice the magnitude of the highest mean density recorded.

- During all surveys, time effects were significant for all groups except naked goby larvae, which exhibited no significant time effects.

E.7.7. Significance and Critique of Findings

- For bay anchovy eggs, the absence of significant differences between densities from discrete-depth and oblique tows suggests that eggs were homogeneously distributed in the water column.

- For bay anchovy eggs, the lower values observed at plant-site stations could be interpreted as evidence of depletion of eggs, due either to entrainment loss or to less spawning in the plant vicinity, as suggested by Lubbers and Mihursky in 1976 (Ref. 50).

- For hogchoker eggs, higher values at the plant site may be related to the greater depth of the water column in the intake channel. Hogchoker spawn near the bottom, and intake flow of deep water along the intake channel may cause egg densities to be higher there than at reference locations.

- For bay anchovy larvae, the absence of significant differences between locations is, in part, a function of the large variance among samples (i.e., data are insufficient to detect differences that may exist).

- The higher densities of naked goby larvae at the plant site and Rocky Point may reflect the presence of preferred spawning habitat at those locations (i.e., rip-rap or rock bottom).

- Data may indicate a possible plant effect on bay anchovy eggs, i.e., values in the plant vicinity are lower. The significance of the depletion cannot be evaluated without knowledge of its extent. Continued higher densities of juvenile and adult populations (see Appendices E.13 and E.14) suggest that the depletions have not caused decreases in the stock inhabiting the Calvert Cliffs area.

- Higher densities of hogchoker eggs and naked goby larvae occurring in plant-site samples suggest that the area is a preferred spawning site. Man-made environmental modifications (i.e., dredged canal plus rock rip-rap) may have created new habitat, so that plant-related losses may be balanced by enhanced spawning levels.

Table E.7-1. Results of a hierarchical ANOVA on bay anchovy egg data; effects tested for are station and time within station.

Date	Effect	df	Sums of Squares	Mean Square	F-ratio
July 7-8, 1976	Station	3	20.2794	6.7598	4.42*
	Time ⊂ Station	20	30.5994	1.5300	7.20**
	Error	120	25.4963	0.2125	
	TOTAL	143	76.3751		
July 28-29, 1976	Station	3	52.0503	17.3501	5.89**
	Time ⊂ Station	16	47.1339	2.9459	12.12**
	Error	100	24.3035	0.2430	
	TOTAL	119	123.4877		
Aug. 16-17, 1976	Station	3	1.8628	0.6209	0.78
	Time ⊂ Station	16	12.7515	0.7970	7.81**
	Error	100	10.1969	0.1020	
	TOTAL	119	24.8112		

* Indicates significance at the $p = 0.05$ level.

** Indicates significance at the $p = 0.01$ level.